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COMPONENTS AND SUB-ASSEMBLIES

SNAP 8 RADIATION EFFECTS TEST PROGRAM

VOLUME III

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Prepared under Subcontract to Aerojet General Corp., Azusa, Calif., under Contract No. NAS 5-417 by

GEORGIA NUCLEAR LABORATORIES OF LOCKHEED-GEORGIA CO.

Dawsonville, Ga.

for

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FOREWORD

This report and the results described herein (originally issued as Georgia Nuclear Report ER 7644) cover irradiation of selected components and subassemblies at the Radiation Effects Reactor, Georgia Nuclear Laboratories, Dawsonville, Georgia.

This work was done under subcontract for the Aerojet General Corporation (NASA Contract No. NAS 5-417) in support of the SNAP 8 Radiation Effects on Materials and Components Program. The contract and subcontract were under the technical management of H. O. Slone and A. W. Nice, respectively, of the NASA Lewis Research Center.

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1.0 TEST PERFORMANCE SUMMARY

The test herein reported was performed in accordance with the Experimental Design Manual, Electronic Components and Subassemblies. The summary is presented to familiarize the reader with the test history. Detailed procedures and methods may be found in the Experimental Design Manual.

All material and test specimens were selected by and received from the Aerojet-General Corporation. The test included selected components and operating assemblies. Twelve of each of the following specimens were included in the test:

COMPONENTS

Diodes: 1N3888, 1N2539, 1N3878, 1N547, GE-90*, GE-91*, GE-92*

SCR's: 2N-1778

Resistors designated GE-86* and GE-87*

Capacitors: 10CPM174 and GE-89*

Subassemblies: Voltage Sensing, Magnetic Amplifiers, Frequency Sensing (4 diode), Frequency Sensing (8 diode), SCR Trigger and Control

The specimens were divided into two major catagories with half of the specimens for the 160°F and half for the 100°F radiation tests. Each category was subdivided into irradiation specimens and control specimens. The division and identification is detailed in the design manual.

The environmental chamber was of the controlled heat sink type and was fully enclosed and thermally insulated. A helium atmosphere was maintained over the specimens with helium being constantly added to make up for the loss through the small leaks. Water was used as the heat transfer fluid.

* Aerojet-General Corp. designations.

The semiconductor components were mounted on finned heat sinks which in turn were mounted on metal aluminum plates. The plates were mounted on the heat sink. The actual temperature of the components was not controlled in that each stabilized at its own particular temperature. The effect of localized temperature changes were evident during the test. The presence of the 400 cycle excitation raised the temperature of the 1N3878 components approximately 10°F during the test. The temperature of the heat sinks was also raised due to the increased forward drops in the diodes themselves.

The thermocouple locations are shown in Figures 3 and 4.

The temperature range for all the thermocouples on the 160°F test was $157^{\circ} \pm 3^{\circ}$F except for the thermocouple mounted on the diode heat sink which registered 150°F $+10^{\circ}$F.

The temperature range for all the thermocouples on the 100°F test was 105°F + 3°F except for the thermocouple mounted on the diode heat sink which registered 106°F + 10°F.

Short downward excursions in temperature were evident at times when water was added to the system and when checks were made of the ice bath. Small variations were also evident at the water inlet locations.

The 160°F irradiation was conducted with the reactor operating at 1 MW, 3 MW and shutdown. This mode of operation was selected to detect rate effects.

The number of data cycles planned in the design manual was not reached because of the accent on backup or manual data and the long time required to complete each data cycle. The initial phase of the 160°F test was conducted with the integrated exposure being reached in steps with data taken at each step to evaluate the effect of dose rate on component performance. The reactor cycle in the second or 100°F irradiation was conducted in conformance with the design manual until the prescribed nuclear dose of 2×10^{11} n/cm^2 had been reached since no rate effect was apparent during the first run. When the designated dose had been reached, the power level was increased to 3 MW and the run continued for 10.4 hours. The LiH shield was then removed and the power level decreased to 1 MW and the run continued for 2.0 hours. The power was raised to 3 MW for 2.9 hours to the end of the irradiation. The nuclear environment was controlled in this manner to show where radiation effects occurred and to give better definition to component and subassembly radiation tolerances. The reactor operating profile and dose rates are shown in the section on nuclear environments.

The 100°F irradiation was conducted as soon as the specimens could be installed following the 160°F test. This procedure was followed to keep wiring errors at a minimum. The high radiation tolerances and the absence of rate effects on the 160°F test article made this feasible and precluded the necessity of periodic shutdowns. The test had originally been planned with a month's separation between the two runs.

The test program was conducted in conformance with the design manual except as noted in this report.

Figures 1-1 and 1-2 show the irradiation and control environmental heat sinks prior to the mounting of the specimens. The studs for mounting the panels are evident.

Figure 1-3 is the control heat sink with the test articles in place. The thermocouple locations are indicated.

Figures 1-4 and 1-5 show the irradiation test aricles mounted on the heat sink and the leads partially attached. The leads were later connected to the test articles to the junction board in the car pits. Thermocouple locations are also shown on Figure 1-4.

Figure 1-6 is the automatic data system used to measure and record component operating characteristics. The digital voltmeter, flexowriter-tape punch, card programmer, programmable power supply and switching system may be seen.

The subassembly measuring system is shown in Figure 1-7. The circuit diagrams, test procedures and channel identification were conveniently placed for ready reference.

The resistance and capacitance measuring system is shown in Figure 1-8.

Figure 1-9 shows the backup or manual data panels for the assembly. Note the quantity of terminals used for this phase of the test. Switch panels controlling power to each subassembly were installed after this picture was taken.

The test car is shown in Figure 1-10 and 1-11 prior to placing the front cover in place and positioning it at the reactor. The hot water reservoir and heat exchanger are visible in Figure 1-10. The LiH shield is shown in the raised position in Figure 1-11. Also shown are lead wires going to the junction panel in the car pit.

Figure 1-12 shows the construction of a typical voltage divider box used on the subassembly data sustem.

Figure 1-13 shows part of the automatic switching equipment employed in the components excitation and measuring system.

The load banks are shown in Figures 1-14 and 1-15.

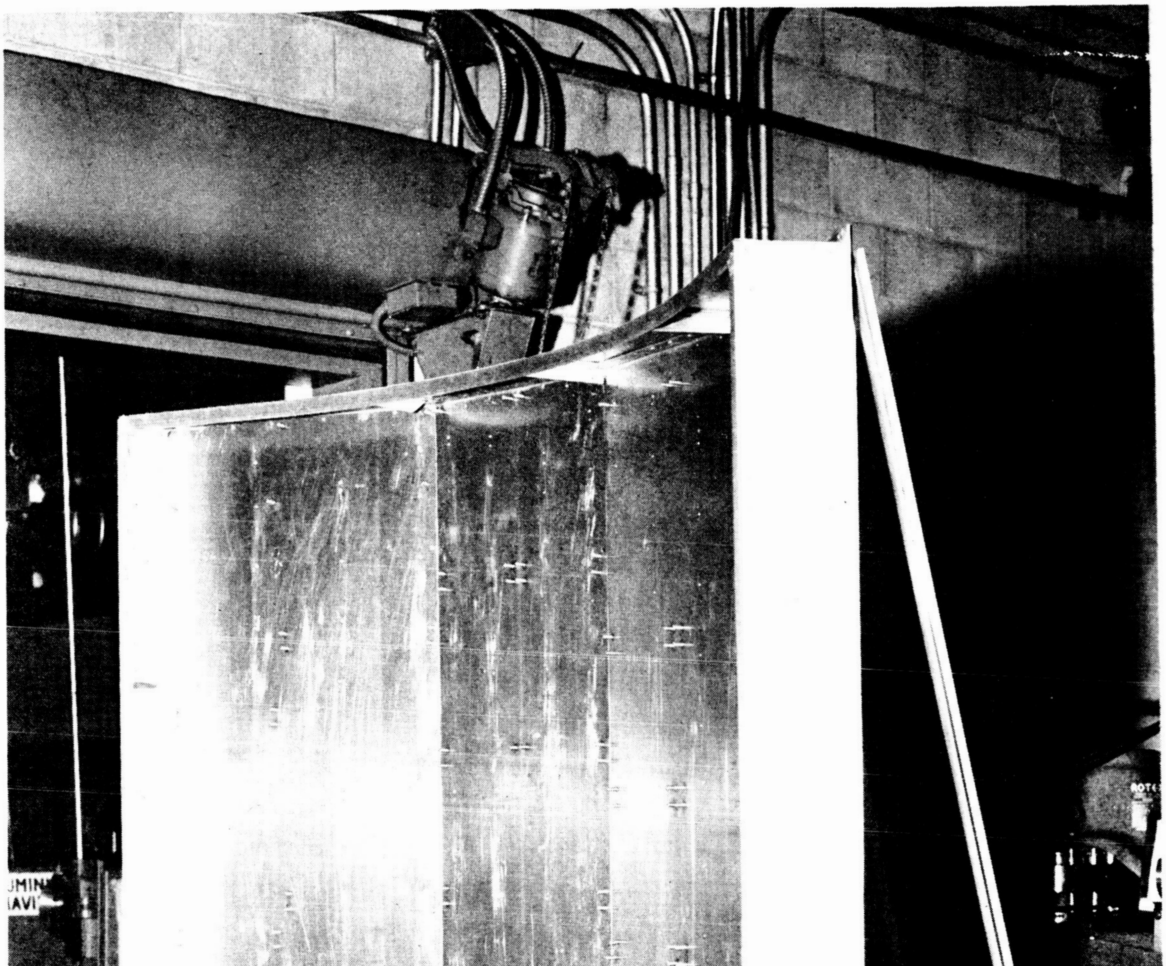


FIGURE 1-1 IRRADIATION HEAT SINK CHAMBER DURING CONSTRUCTION

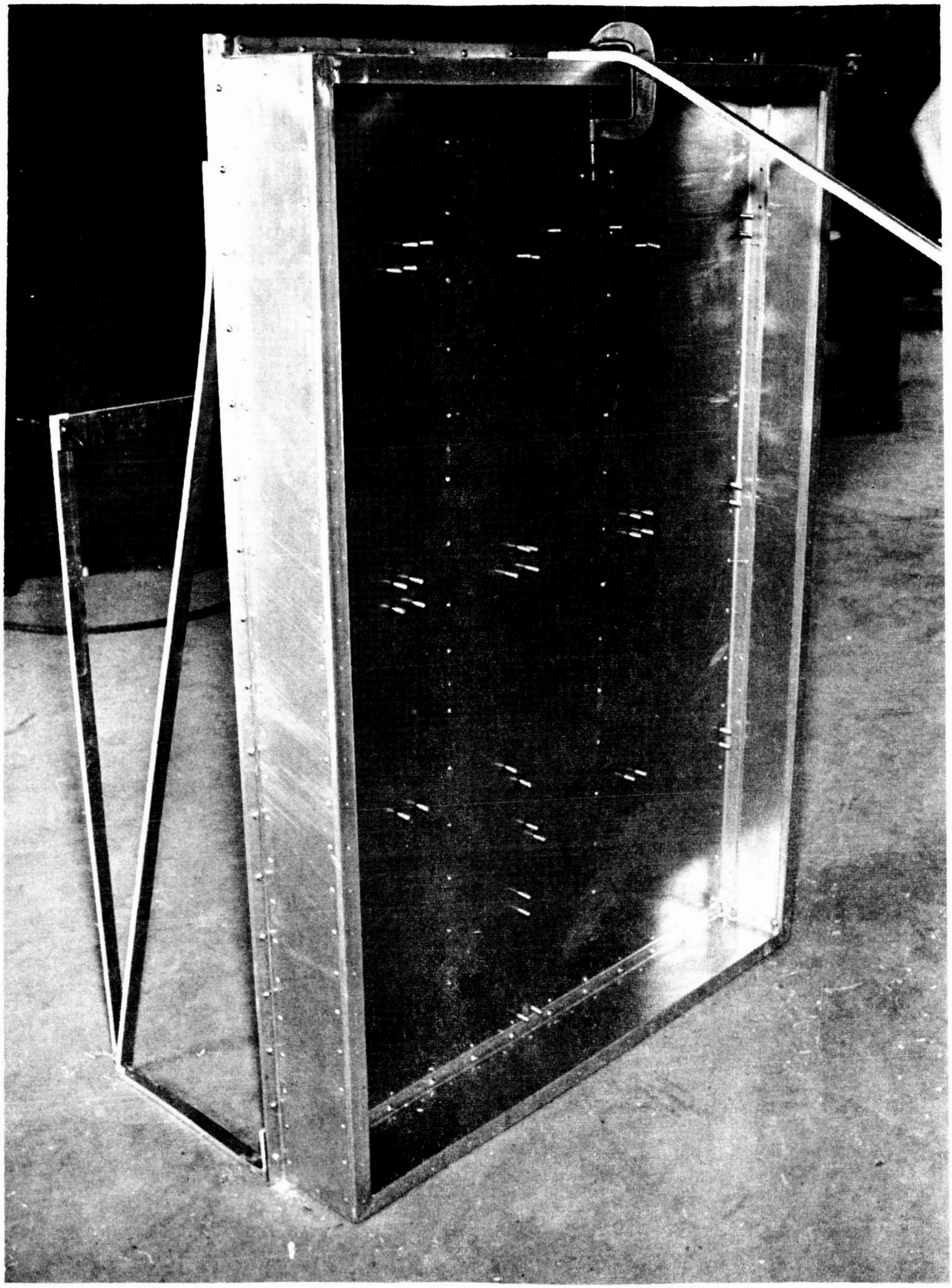


FIGURE 1-2 CONTROL HEAT SINK CHAMBER DURING CONSTRUCTION

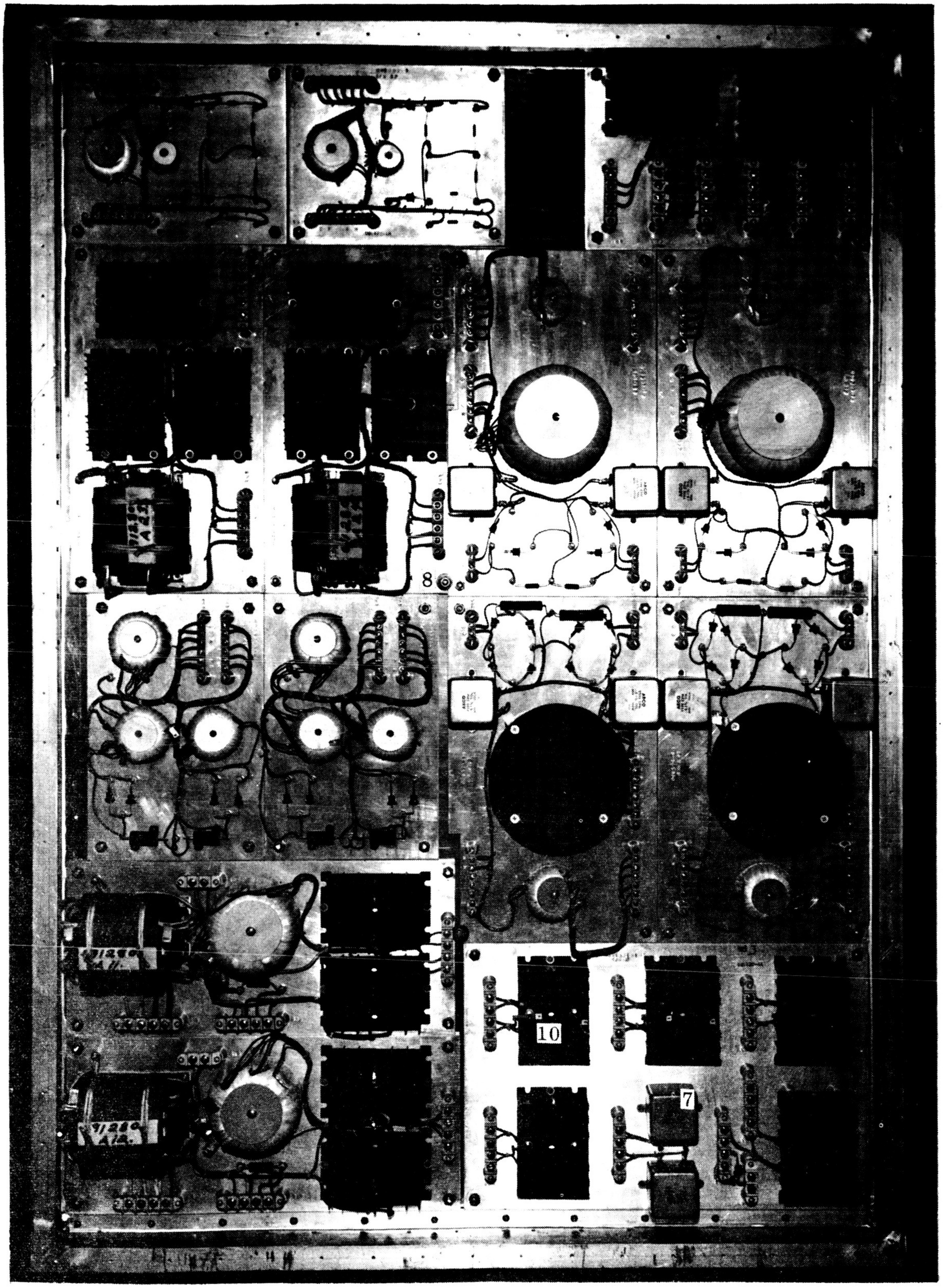


FIGURE 1-3 CONTROL TEST PANELS MOUNTED IN HEAT SINK CHAMBER

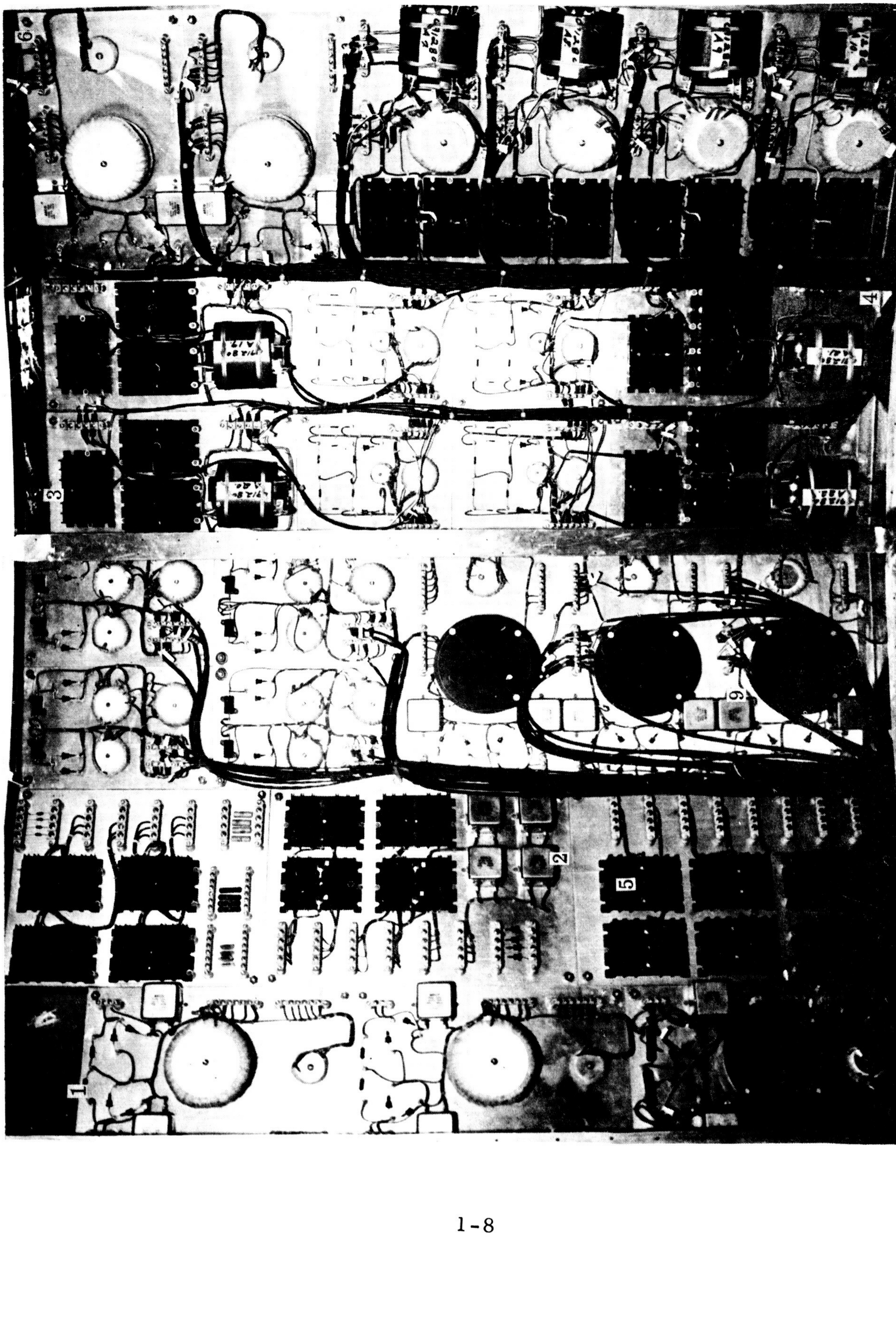


FIGURE 1-4 IRRADIATION TEST PANELS MOUNTED IN HEAT SINK CHAMBER

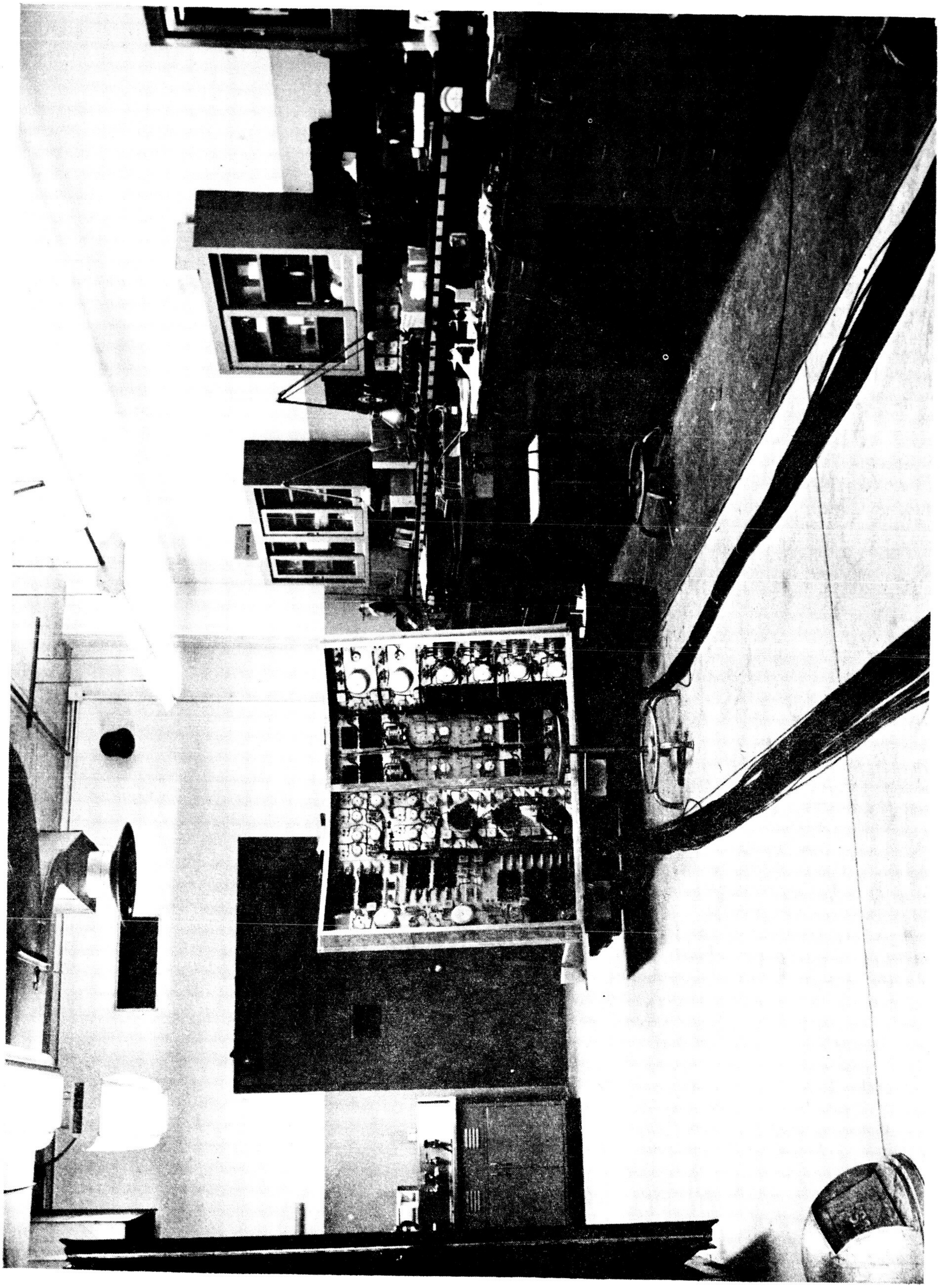


FIGURE 1-5 IRRADIATION TEST PANELS DURING HOOKUP

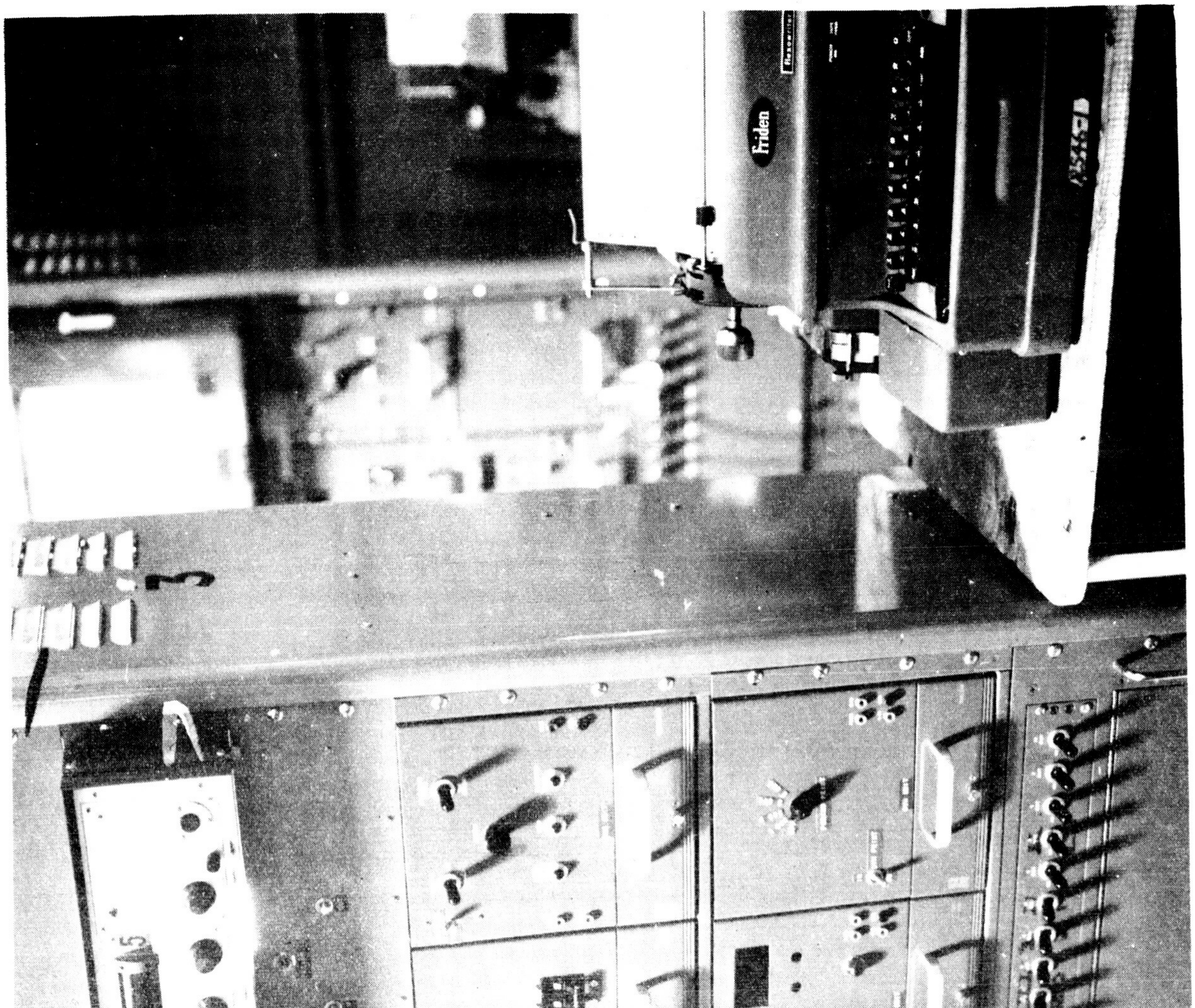


FIGURE 1-6 COMPONENTS INSTRUMENTATION SYSTEM

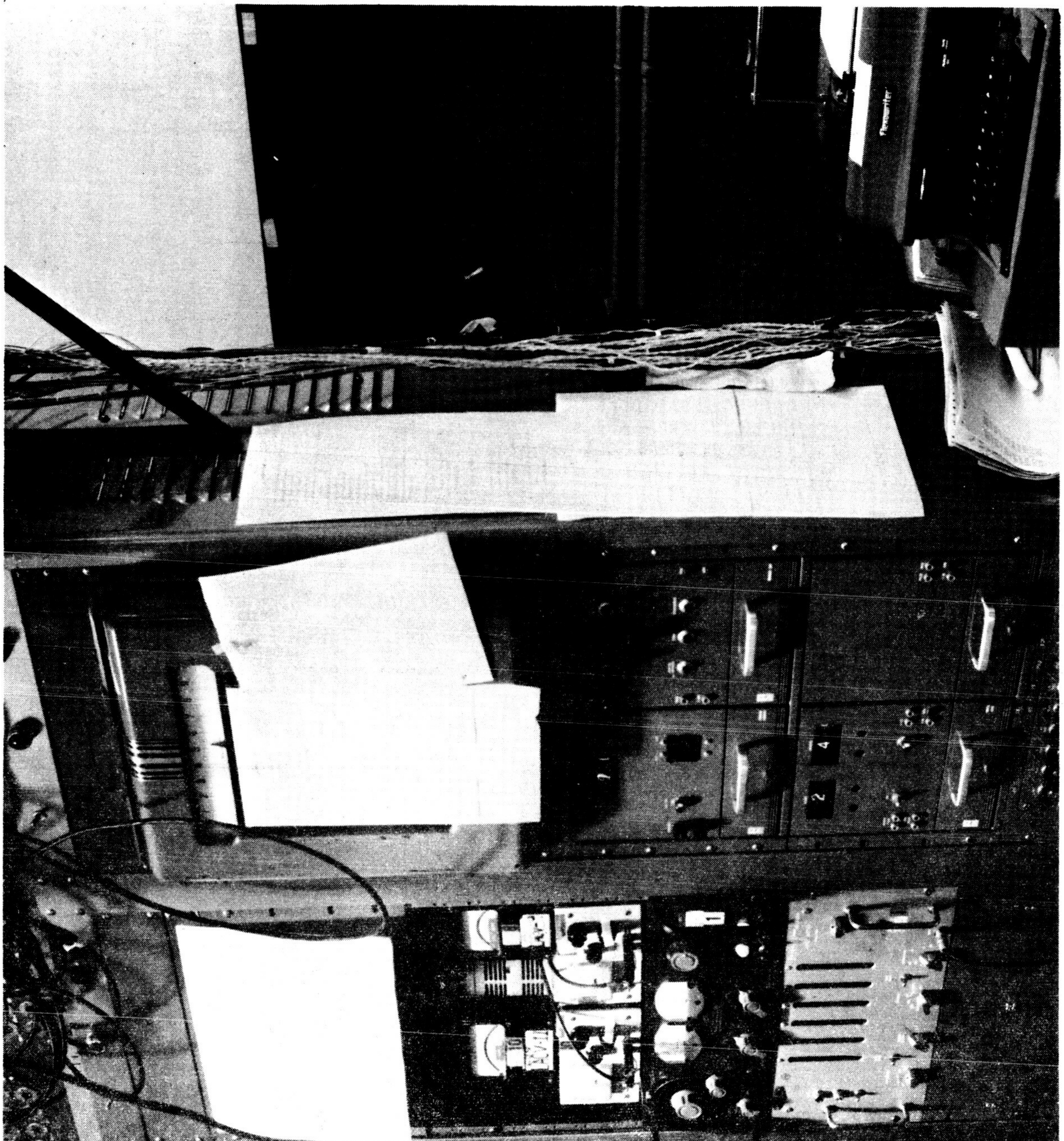


FIGURE 1-7 SUBASSEMBLIES INSTRUMENTATION SYSTEM

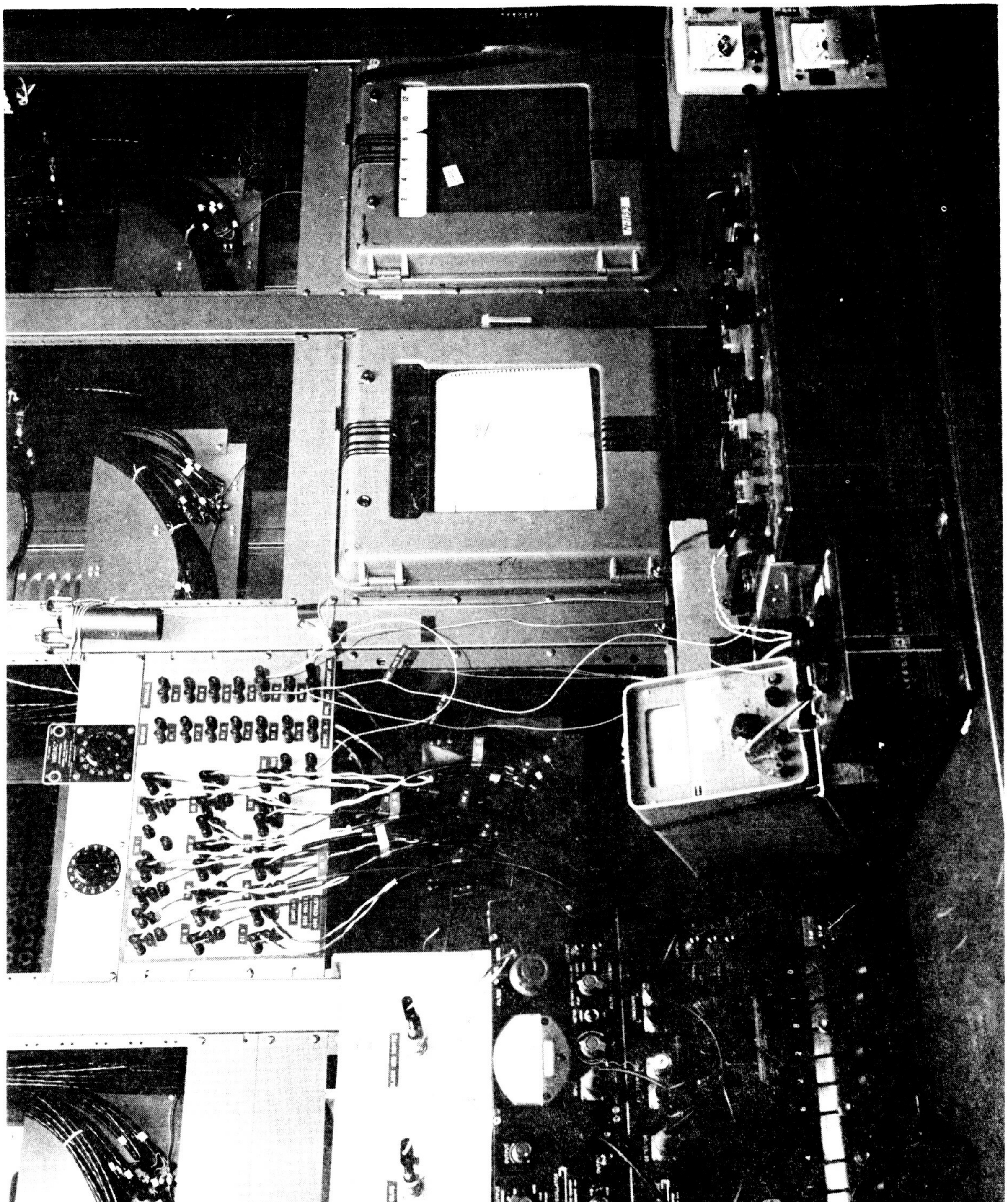


FIGURE 1-8 CAPACITORS AND RESISTORS INSTRUMENTATION SYSTEM

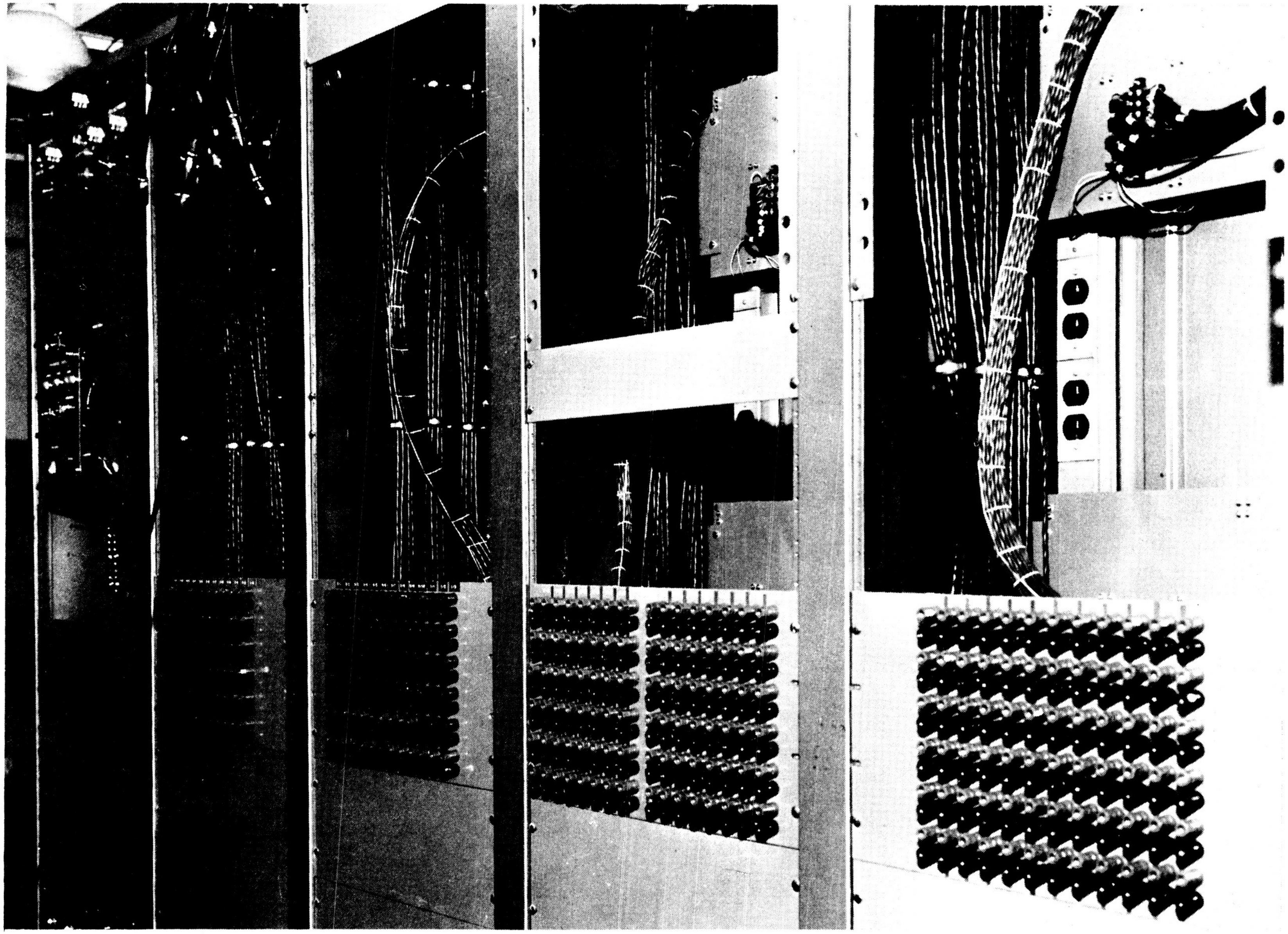


FIGURE 1-9 SUBASSEMBLIES "BACKUP DATA" PANELS

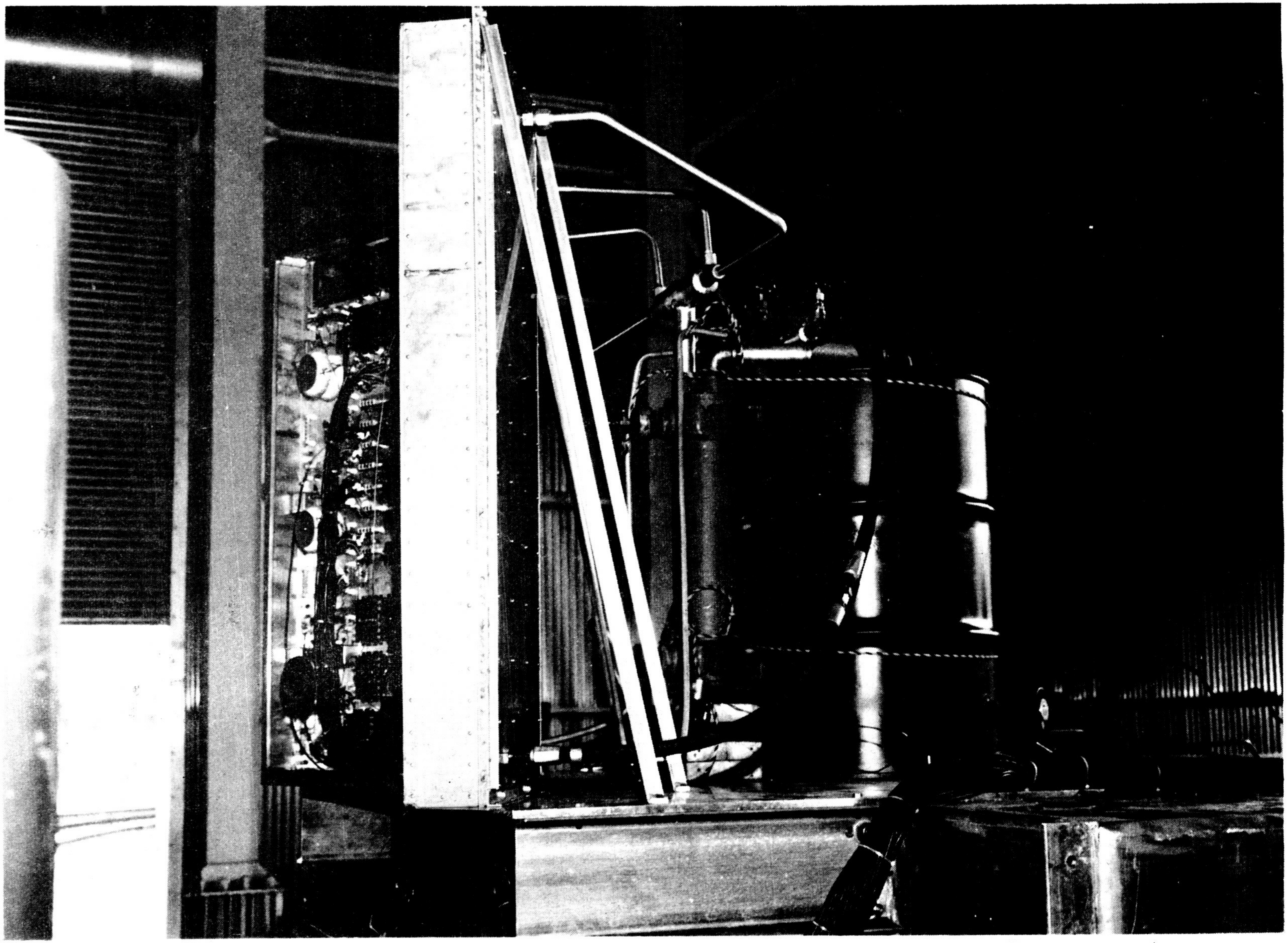


FIGURE 1-10 IRRADIATION TEST CAR AT REACTOR PRIOR TO POSITIONING AND CLOSING

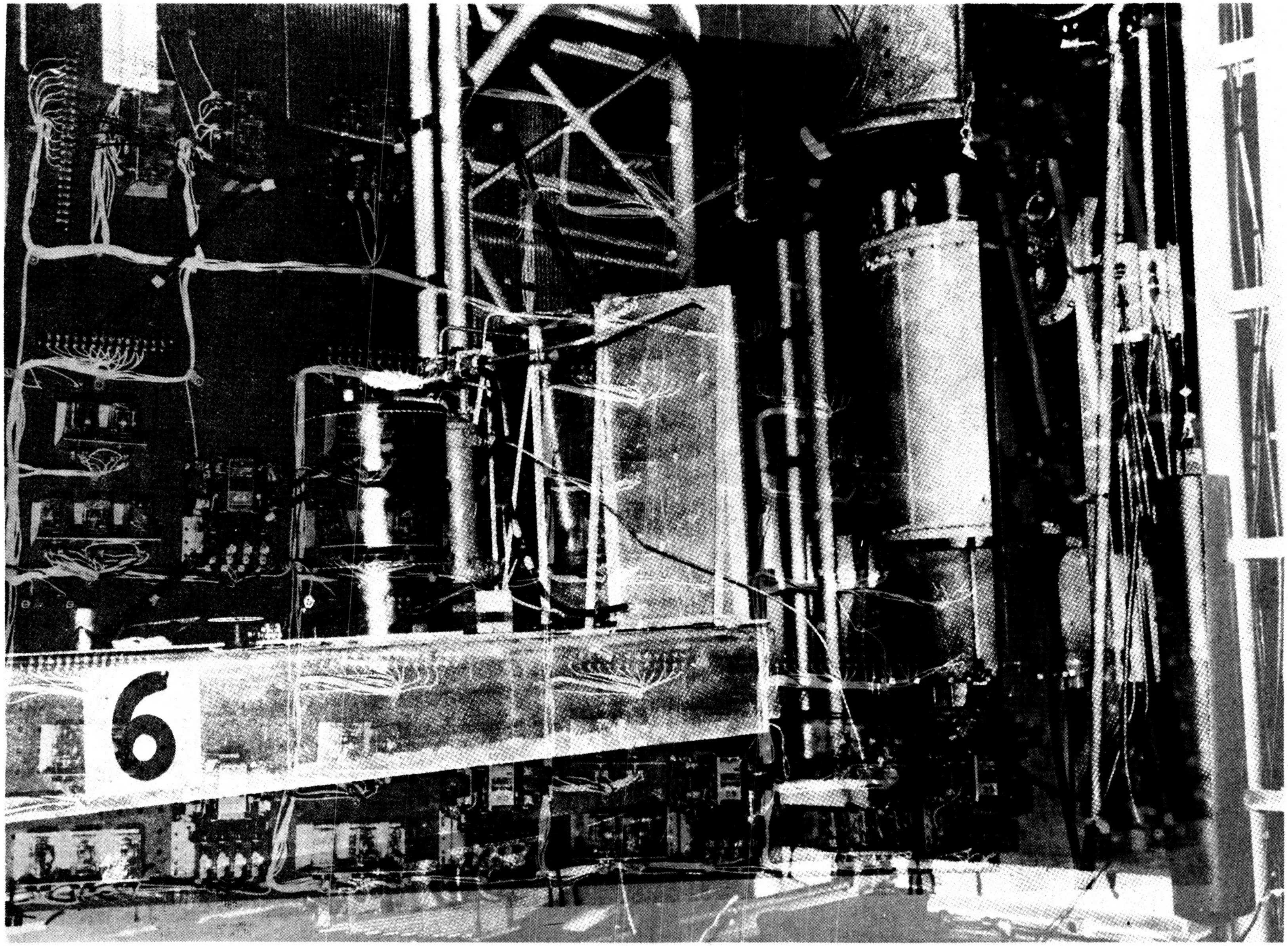


FIGURE 1-11 IRRADIATION TEST CAR SHOWING LiH SHIELD AND REACTOR

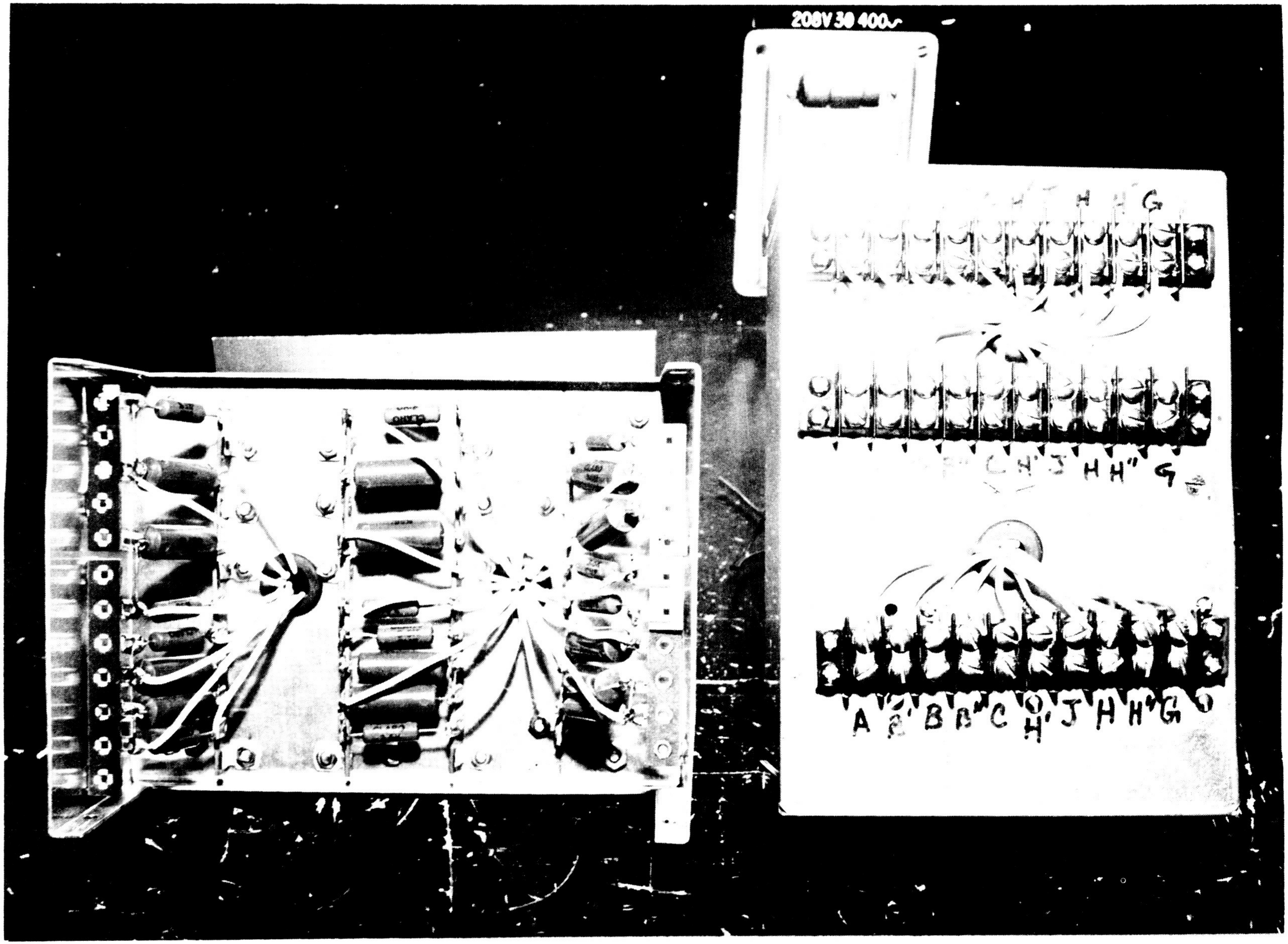


FIGURE 1-12 INSTRUMENTATION VOLTAGE DIVIDER BOXES

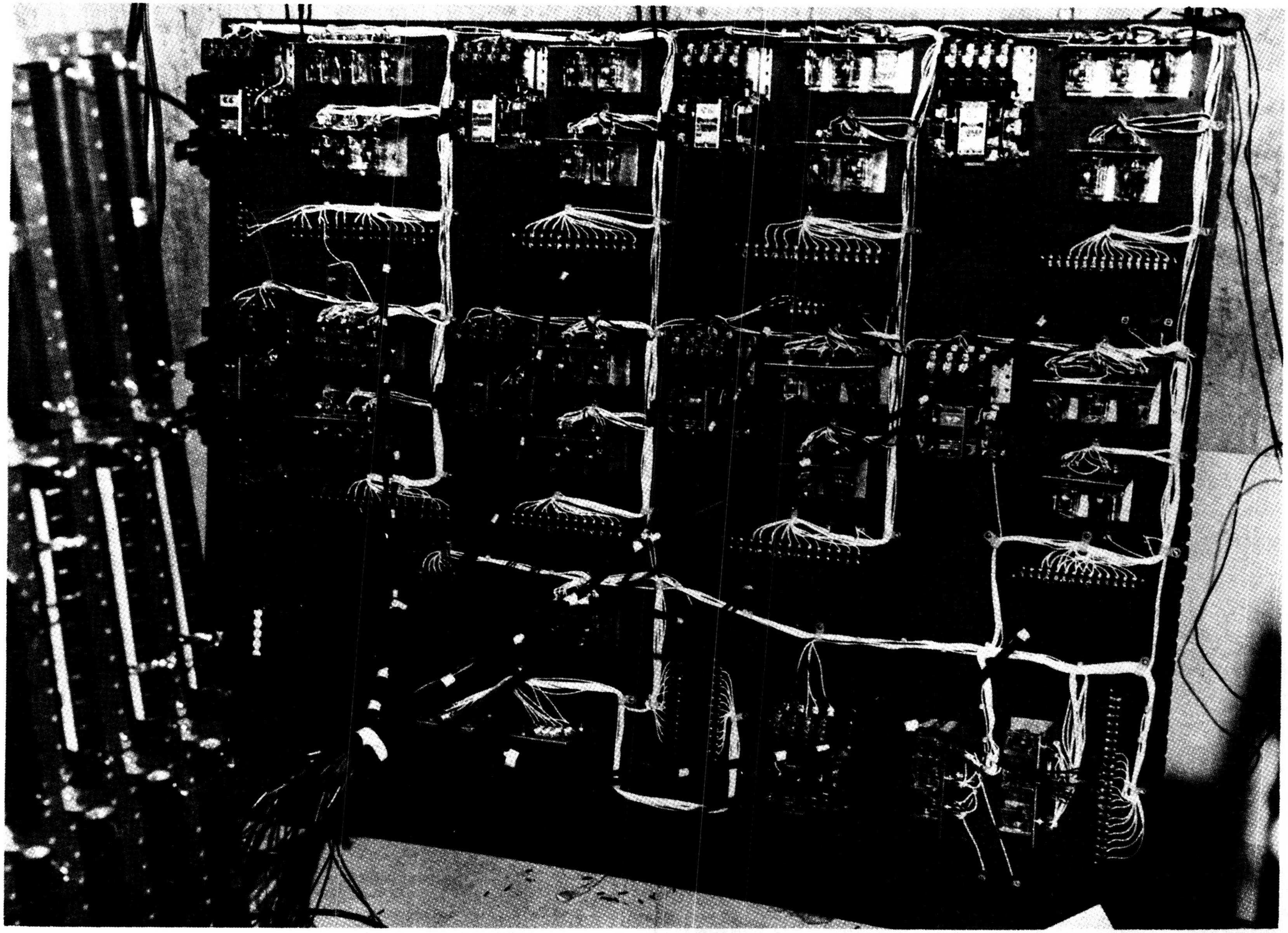


FIGURE 1-13 COMPONENTS EXCITATION - MEASURING CIRCUITS SWITCH PANEL

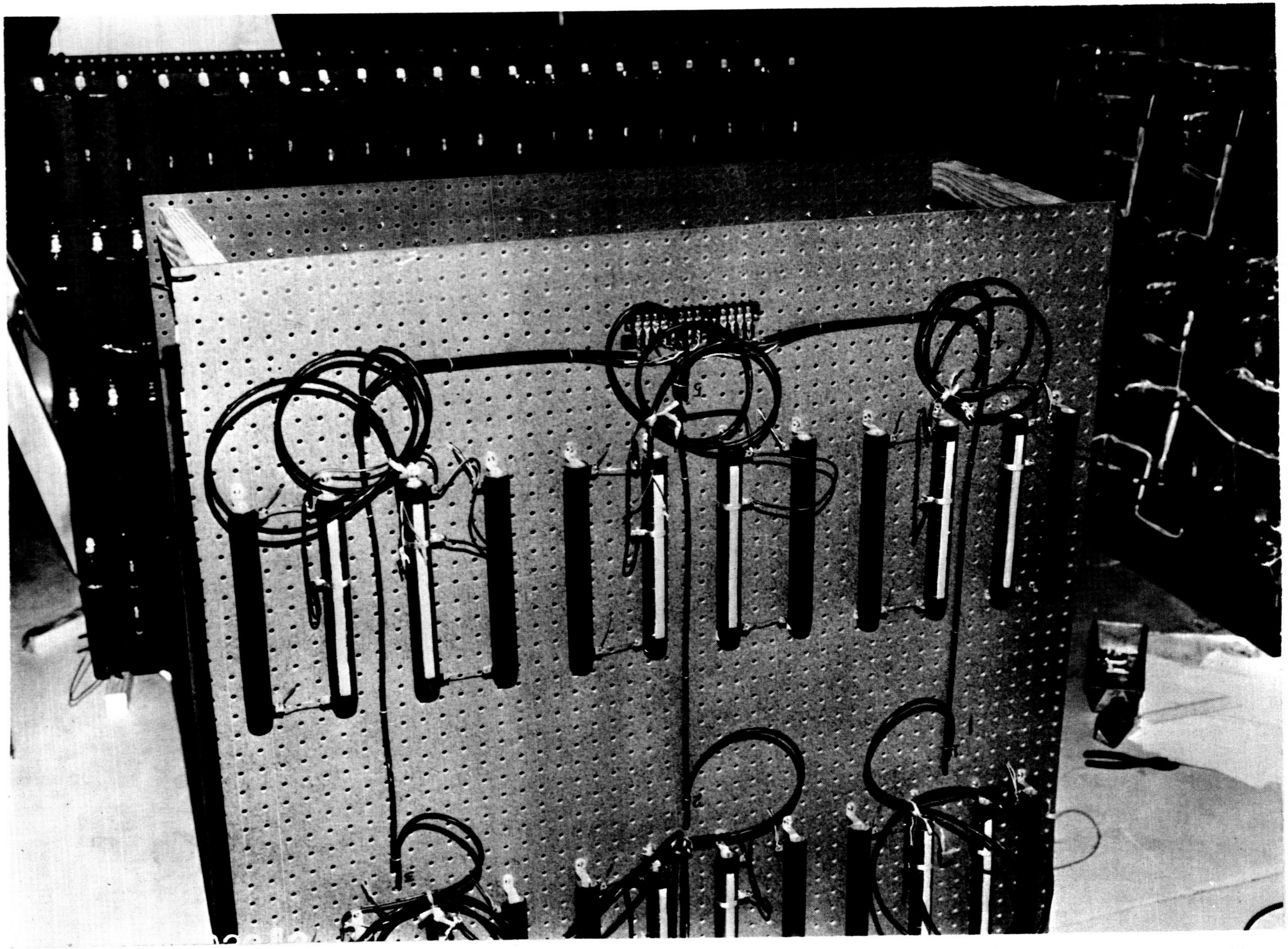


FIGURE 1-14 COMPONENT LOAD BANKS AND SWITCHING SYSTEM ARRANGEMENT

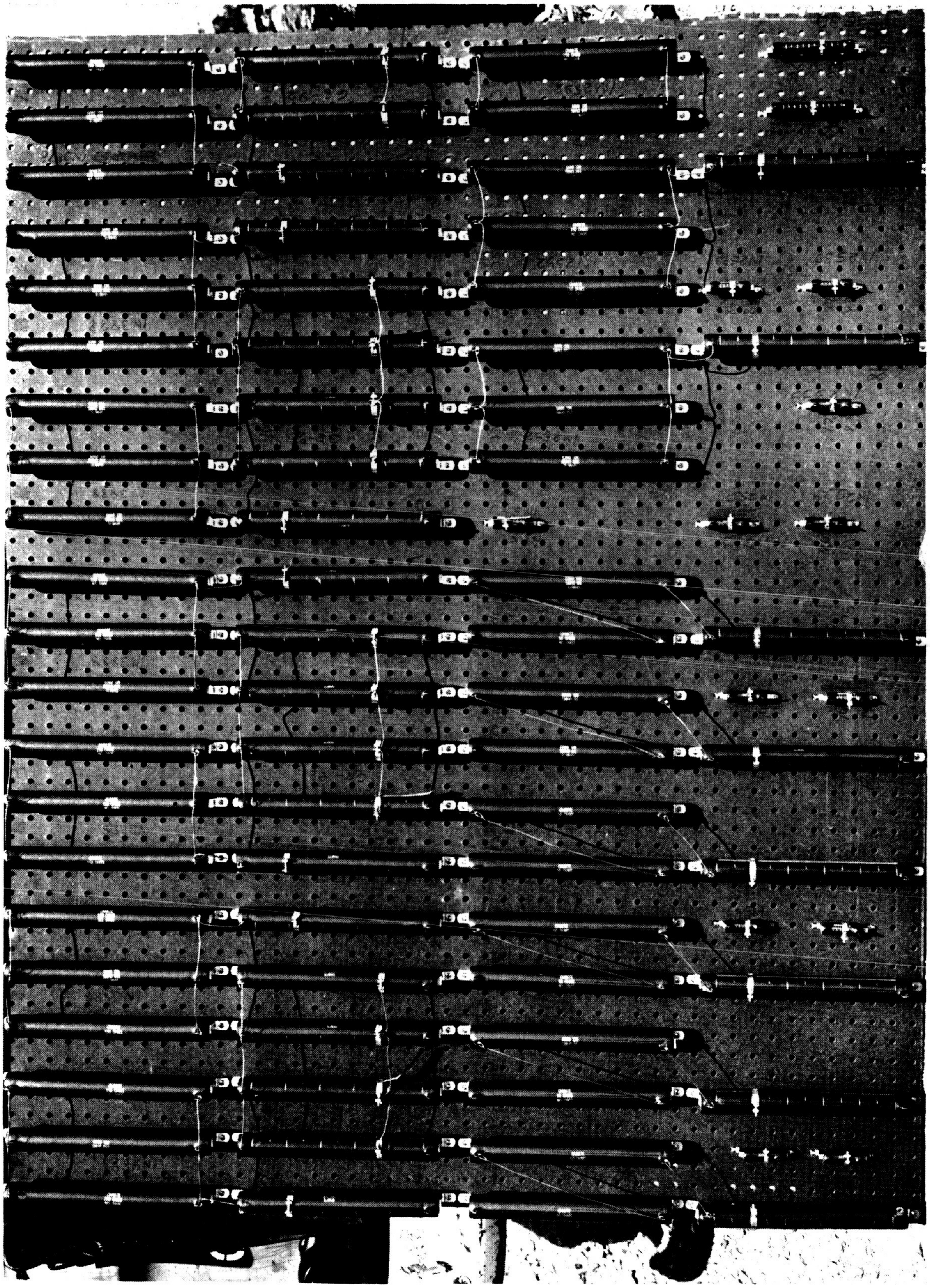


FIGURE 1-15 TYPICAL LOAD BANK ARRANGEMENT

2.0 SUMMARY OF RESULTS

The 160°F test at 2×10^{11} nvt showed barely discernible changes in the subassembly operation due to irradiation effects. Slight increases in reverse leakage and forward drop of the diodes were noted. The 100°F test, having the higher nuclear exposure, revealed large changes in both components and subassemblies. The data from both tests indicate no difference due to temperature. The accent in this report is, therefore, on the second or 100°F test.

The diodes underwent changes as expected. The forward voltage drops increased and the reverse leakage currents increased. In general, the effect of radiation is to destroy the junction and reduce the semiconductors to intrinsic semiconductor material. The exposure in these tests were not sufficient to do this but the trend is in that direction.

Changes in operational characteristics of all subassemblies can be explained by the changes that occurred in the semiconductors. Bench tests performed after the irradiation had been completed where "control" semiconductors were substituted for the irradiated ones, returned all subassemblies to normal operating conditions. No other components (magnetic cores, transformers, resistors, capacitors, etc.) changed sufficiently to be detectable in the operating characteristics.

Most of the subassemblies employed the principal of differential output and one would expect most of the changes to balance out. Radiation changes to semiconductors are well known to show considerable scatter and this scatter was evident in these tests. The circuits became unbalanced and shifted the outputs accordingly. This phenomena was especially evident in the voltage sensing units.

The SCR's suffered increased forward blocking currents, reverse leakage current and increased firing voltages. At the end of the test many of the SCR's would not fire. Some would fire but with the firing voltages that exceeded the power rating of the gate. The SCR's began to show evidence of transistor-like operation with very low betas.

The resistors and capacitors showed no change with radiation. Slight change due to temperature were evident.

Post irradiation inspection revealed that some, but not all, of the ceramic terminal strips turned a bluish grey color. The anodized coating on a few of the heat sinks turned a copperish color.

The adhesive tape on the magnetic cores became exceptionally sticky and would adhere readily to most surfaces.

3.0 COMPONENTS

General

The discussion of results is broken down into three sections; two sections deal with diodes and one section with the SCR's. The diodes are categorized according to the current rating; high current and low current. Five types comprise the high current group wherein the forward current test conditions ranged from 120 milliamperes to 9 amperes. Three types make up the low current group wherein the forward current test conditions ranged from 5 to 150 milliamperes. The high current group includes the GE-91, the Hughes 1N3888, the Bradley 1N2592, the Hughes 1N3878 and the GE-92. The low current group includes the RCA 1N547, the Bradley 1N2539 and the GE-90.

Forward and reverse characteristics for a typical diode of each group are plotted against neutron exposure and all other specimens with their respective typical data points are included in tabular form. The tabulated data represents about one-fifth the total recorded during the 100°F test. The forward characteristics are plotted for all three conditions of forward current whereas the reverse characteristics are plotted for the highest peak inverse voltage. The curves are plotted primarily for the 100°F run, but to show trends, if any, points are shown on the same curve for the 160°F run. No plots or tables are included for reverse characteristics on the 160°F run due to a lack of data which resulted from circuitry problems. A detailed explanation is found in succeeding pages. The reverse leakage currents made at the RER cannot be compared to the laboratory measurements due to extraneous noise, leakage and ionization. Relative changes can be noted and applied to the absolute measurements made in the laboratory.

Pre and post irradiation bench test data at ambient temperature for the 100°F specimens and post irradiation bench data for the 160°F specimens are included in tabular form with typical forward and reverse characteristics shown graphically.

These bench tests were preformed in addition to the tests outlined in the Design Manual to verify data taken during the reactor run.

The bold line found on the tables denotes the point at which the LiH shield was removed.

3.1 LOW CURRENT DIODES

Three types of diodes are discussed in this section; the RCA 1N547, the Bradley 1N2539 and the GE-90. This group comprised the diodes tested where forward current conditions ranged from 5 to 150 milliamperes. Both tabular and graphical means are used to report the results of the tests.

Figures 3-1 and 3-2 show the pre and post irradiation bench data for forward and reverse characteristics for a typical diode of each type. Tables 3-1 thru 3-24 include the data for all diodes with an asterisk indicating the diode plotted.

Figure 3-2 indicates the increase in the level of reverse leakage from the pre-test value. Normally, the current increased by a factor of approximately 14 on the GE-90 to 33 on the 1N2539.

Figure 3-1 indicates a definite increase in the level of forward voltage drop from the pre-test value. The spread of voltage drop versus forward current ranged from 45 millivolts on the 1N547 to 118 millivolts on the GE-90 in pre-irradiation test data whereas the spread ranged from 294 millivolts on the 1N2539 to 1.033 volts on the 1N547 for the post irradiation test data. The increase in the forward drop at the lower currents ranged from a factor of 1.17 on the GE-90 to 2.69 on the 1N547. The shift at the higher forward currents ranged from a factor of 1.85 on the GE-90 to 3.85 on the 1N547.

Figures 3-3, 3-5 and 3-7 show forward voltage drop versus neutron exposure for the three types of diodes. Tables 3-4 thru 3-24 include the data for all diodes with an asterisk indicating the diode plotted. In general, no significant trend is exhibited in any of the three types until an exposure of approximately 6×10^{11} n/cm^2 is reached. A marked increase in the slope is particularly apparent when the lithium hydride shield was removed. The voltage drop on the GE-90 at the lowest forward current appears to show little increase with exposure whereas the higher forward currents show a marked increase.

Figures 3-4, 3-6 and 3-8 show reverse leakage versus neutron exposure of the three types of diodes. No apparent continuous trend is noticeable in any of the three types of diodes until an exposure of approximately 4×10^{12} n/cm^2 on the 1N547, 5×10^{11} n/cm^2 on the 1N2539, and 2×10^{11} n/cm^2 on the GE-90 is reached. It is also quite ~~apparent that~~ when the lithium hydride shield was removed the increase in leakage was substantial. This was caused by the increased neutron and gamma rates.

In Figure 3-8 the reverse leakage current versus neutron flux for the GE-90, a temporary trend toward higher leakage current is first observed at an exposure of approximately 2×10^{11} n/cm^2. A shift change occurred at the time where the reactor power was decreased to zero. Following startup, this trend did not continue since it was probably an ionization buildup.

The diodes and SCR's were tested during both the 160°F and 100°F runs on the Automatic Component Measuring System as indicated in the Experimental Design Manual with the following exceptions:

(1) In Figure 3-16 of the Experimental Design Manual, there is a sneak circuit which allows part of the cathode potential lead to draw current. The sneak circuit was detected after the 160°F test was completed. Additional relays were added to the basic system of Figure 3-16 to eliminate it for the 100°F test.

(2) During the first part of the 160°F test the reverse leakage of the diodes, as read across the current shunts in Figure 3-16 of the Experimental Design Manual, was high. The reason was that the constant current supply was not perfectly isolated from ground. This condition was corrected by moving the normally open contact of K5 to the shunt lead of the constant current supply, rather than as shown in Figure 3-16.

(3) The indicated reverse leakage was further reduced by grounding the end of the constant voltage supply that ties to the shunts - thus using the grounded shields as guard circuit for the measurements.

(4) The constant voltage supply in Figure 3-16 of the Experimental Design Manual actually consisted of the programmable supply indicated and also a 240 volt constant voltage supply which was automatically switched in series when higher voltages were required.

Near the beginning of the 100°F test, a faulty switching circuit caused the 240 volt supply to be inadvertently switched in series when it was not desired, thus applying 240 volts in excess of the nominal test values to the 1N547's, 1N2539's, and the GE-92's. This occurred three or four times for each test condition for each diode, before the malfunction was detected.

The 1N547's, which are rated at 600 volts, and the 1N2539's, which are rated at 400 volts, were therefore tested at nominal values of 260, 290, and 310 volts rather than at 20, 50, and 70 volts. A decision was made at this point to conduct the remainder of the test at these new test values. The new values began at an accumulated exposure of 1.6×10^{11} n/cm^2 and before any apparent change in the diode characteristics had occurred.

The GE-92's, which are rated at 200 peak inverse volts and have an avalanche breakdown somewhere between 250 volts and 550 volts, were tested at 290, 340 and 440 volts during the period of malfunction. One of the GE-92's avalanched under these conditions. The GE-92's, being in a slightly higher flux, had been exposed to about 1.9×10^{11} n/cm^2 at this time.

With the stated exceptions, the circuitry for the diode and SCR components performed its job well. In almost all cases the test voltages and test currents were within a few percent of the nominal values of Table 3-2 in the Experimental Design Manual. Reverse leakage currents less than 10^{-7} amperes were not detectable because of cable noise.

The 400 cycle excitation to the components sometimes generated voltages in the subassemblies which adversely affected their operation (particularly the SCR units) It became necessary to remove 400 cycle excitation from the components for extended periods of time in order to make measurements on the subassemblies. Excitation was on approximately 70% of the time.

The error introduced by the sneak circuits was calculated on the basis of approximate cable resistance, and is tabulated as follows:

Diode	Run 1 Irrad.	Run 1 Control	Run 2 Irrad.	Run 2 Control	Run 3 Irrad.	Run 3 Control	Error Volts/Amp
GE-90	.0009	.00003	.009	.0003	.018	.0006	.18 Irrad. .006 Control
1N547	.008	.005	.016	.001	.02	.0015	.16 Irrad. .01 Control
1N2539	.008	.005	.016	.001	.02	.0015	.16 Irrad. .01 Control
GE-91	.01	.001	.1	.01	.2	.02	.08 Irrad. .008 Control
1N3888	.02	.005	.16	.04	.3	.08	.08 Irrad. .02 Control
1N3878	.02	.005	.16	.04	.3	.08	.08 Irrad. .02 Control
1N2592	.02	.005	.16	.04	.3	.08	.08 Irrad. .02 Control
2N1778	.02	.005	.16	.04	.3	.08	.08 Irrad. .02 Control
GE-92	.2	.02	.5	.05	.6	.06	.08 Irrad. .008 Control

Values are probable order of magnitude in volts.

The values tabulated in the results do not attempt to correct for this error, because the error tabulation is not of sufficient accuracy. The values given are approximate and most are insignificant.

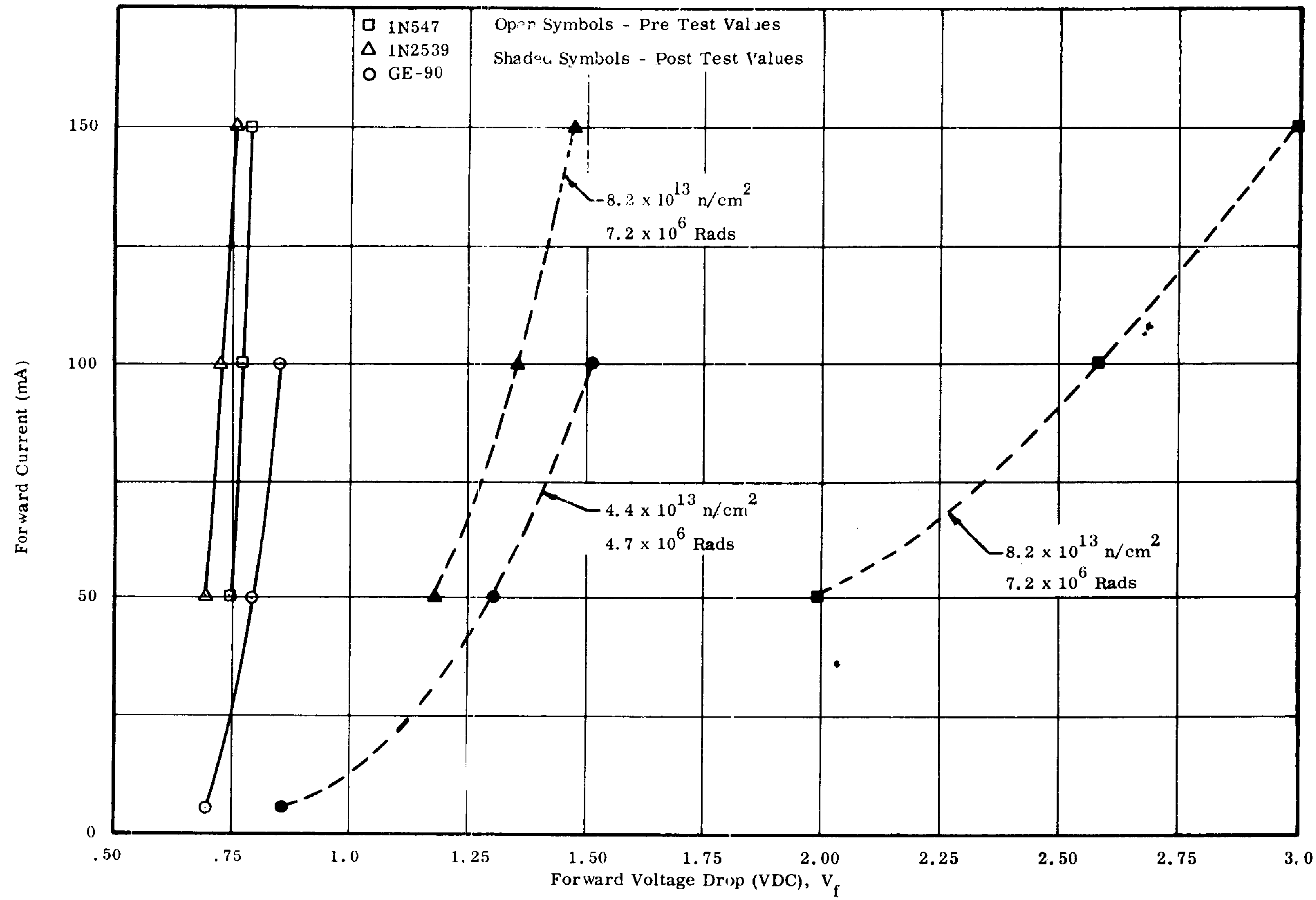


FIGURE 3-1 FORWARD CHARACTERISTICS - LOW CURRENT DIODES, PRE AND POST MEASUREMENTS MADE AT LABORATORY, 100^{o}F

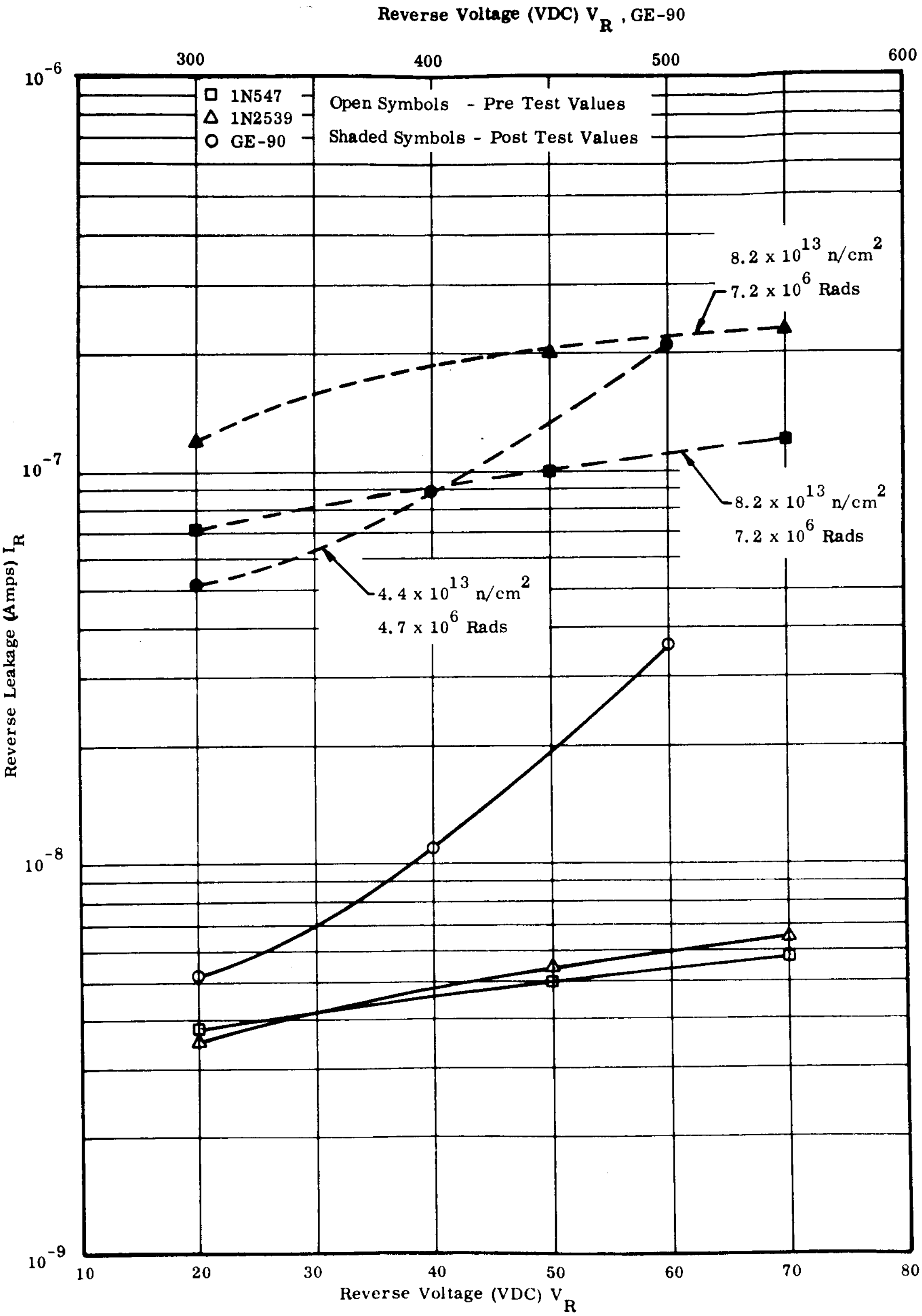


FIGURE 3-2 REVERSE CHARACTERISTICS - LOW CURRENT DIODES, PRE AND POST MEASUREMENTS MADE AT LABORATORY, 100° F

TABLE 3-1 DIODE CHARACTERISTICS, PRE AND POST MEASUREMENTS AT LABORATORY IN2539

Test		Diode Identification	Pre or Post	V_f at I_f 0.050A	V_f at I_f 0.100A	V_f at I_f 0.150A	I_R at V_R 20 VDC	I_R at V_R 50 VDC	I_R at V_R 70 VDC
100° F	Irradiated	D2-1	Pre	0.696	0.728	0.751	3.6 (-9)	5.4 (-9)	6.4 (-9)
			Post	1.181	1.356	1.475	1.2 (-7)	2.0 (-7)	2.3 (-7)
		D2-2	Pre	0.715	0.744	0.762	5.4 (-9)	9.4 (-9)	1.2 (-8)
			Post	1.085	1.228	1.325	1.2 (-7)	1.8 (-7)	2.2 (-7)
		D2-3	Pre	0.709	0.742	0.766	6.5 (-9)	9.5 (-9)	1.1 (-8)
			Post	2.237	2.615	2.915	1.6 (-7)	2.5 (-7)	2.9 (-7)
		D2-4	Pre	0.713	0.743	0.762	9.8 (-9)	1.5 (-9)	1.9 (-8)
			Post	1.567	1.847	2.045	1.3 (-7)	2.0 (-7)	2.4 (-7)
	Control	D2-5	Pre	0.718	0.747	0.765	7.2 (-9)	9.6 (-9)	1.0 (-8)
			Post	0.712	0.738	0.754	4.4 (-9)	9.6 (-9)	1.3 (-8)
		D2-6	Pre	0.713	0.741	0.758	3.9 (-9)	9.2 (-9)	1.3 (-8)
			Post	0.715	0.742	0.759	7.0 (-9)	9.0 (-9)	1.0 (-8)
160° F	Irradiated	D2-7	Post	0.714	0.761	0.790	1.5 (-8)	2.4 (-8)	2.8 (-8)
		D2-8	Post	0.675	0.717	0.743	2.2 (-8)	3.4 (-8)	4.C (-8)
		D2-9	Post	0.697	0.746	0.771	1.6 (-8)	2.5 (-8)	3.0 (-8)
		D2-10	Post	0.671	0.713	0.738	1.7 (-8)	2.5 (-8)	3.0 (-8)
	Control	D2-11	Post	0.709	0.737	0.755	3.2 (-7)	5.3 (-9)	6.2 (-9)
		D2-12	Post	0.706	0.734	0.756	2.0 (-7)	3.1 (-9)	3.7 (-9)

Test	Gamma Dose (Rads)	Neutron Exposure (n/cm^2)
100° F	7.2 (6)	8.2 (13)
160° F	4.4 (6)	1.3 (12)

TABLE 3-2 DIODE CHARACTERISTICS, PRE AND POST MEASUREMENTS AT LABORATORY IN547

Test		Diode Identification	Pre or Post	V_f at I_f			I_R at V_R		
				0.050A	0.100A	0.150A	20 VDC	50 VDC	70 VDC
100° F	Irradiated	D5-1	Pre	0.741	0.769	0.786	3.8 (-9)	5.0 (-9)	5.8 (-9)
			Post	1.992	2.580	3.025	7.1 (-8)	1.0 (-7)	1.2 (-7)
		D5-2	Pre	0.743	0.771	0.788	1.9 (-9)	3.0 (-9)	3.6 (-9)
			Post	2.240	2.865	3.370	6.8 (-8)	1.0 (-7)	1.1 (-7)
		D5-3	Pre	0.732	0.766	0.787	1.9 (-9)	3.1 (-9)	3.9 (-9)
			Post	2.880	3.665	4.450	6.5 (-8)	1.0 (-7)	1.2 (-7)
		D5-4	Pre	0.735	0.767	0.786	1.5 (-9)	3.1 (-9)	4.1 (-9)
			Post	2.995	3.910	4.670	7.3 (-8)	1.1 (-7)	1.3 (-7)
	Control	D5-5	Pre	0.742	0.781	0.802	1,8 (-9)	2.7 (-9)	3.2 (-9)
			Post	0.739	0.772	0.792	3.5 (-9)	4.6 (-9)	4.9 (-9)
		D5-6	Pre	0.734	0.767	0.787	2.2 (-9)	2.9 (-9)	3.3 (-9)
			Post	0.732	0.763	0.780	3.1 (-9)	4.0 (-9)	4.6 (-9)
160° F	Irradiated	D5-7	Post	0.923	1.016	1.074	8.4 (-9)	1.4 (-8)	1.7 (-8)
		D5-8	Post	0.905	0.992	1.055	8.8 (-9)	1.3 (-8)	1.6 (-8)
		D5-9	Post	0.960	1.065	1.128	7.8 (-9)	1.2 (-8)	1.5 (-8)
		D5-10	Post	0.901	0.988	1.045	7.6 (-9)	1.2 (-8)	1.4 (-8)
	Control	D5-11	Post	0.740	0.775	0.794	3.6 (-9)	4.7 (-9)	5.2 (-7)
		D5-12	Post	0.732	0.761	0.778	5.8 (-9)	7.3 (-9)	8.0 (-9)

Test	Gamma Dose (Rads)	Neutron Exposure (n/cm^2)
100° F	7.2 (6)	8.2 (13)
160° F	4.4 (6)	1.2 (12)

TABLE 3-3 DIODE CHARACTERISTICS, PRE AND POST MEASUREMENTS AT LABORATORY GE-90

Test		Diode Identification	Pre or Post	V_f at I_f			I_R at V_R		
				0.005A	0.050A	0.100A	300 VDC	400 VDC	500 VDC
100° F	Irradiated	D6-1	Pre	0.697	0.791	0.815	5.2 (-9)	1.1 (-8)	3.6 (-8)
			Post	0.814	1.305	1.515	5.2 (-8)	8.9 (-8)	2.1 (-7)
		D6-2	Pre	0.678	0.776	0.800	4.0 (-9)	8.1 (-9)	2.4 (-8)
			Post	0.772	1.277	1.485	5.9 (-8)	1.0 (-7)	2.8 (-7)
		D6-3	Pre	0.658	0.763	0.791	2.2 (-9)	3.6 (-9)	8.7 (-9)
			Post	0.669	1.008	1.127	5.4 (-8)	8.6 (-8)	1.8 (-7)
		D6-4	Pre	0.686	0.798	0.841	1.4 (-9)	2.2 (-9)	4.8 (-9)
			Post	0.757	1.220	1.410	5.0 (-8)	8.4 (-8)	1.8 (-8)
	Control	D6-5	Pre	0.690	0.781	0.802	3.5 (-9)	7.9 (-9)	6.5 (-8)
			Post	0.695	0.775	0.804	3.9 (-9)	1.1 (-8)	1.2 (-6)
		D6-6	Pre	0.682	0.779	0.810	2.7 (-9)	4.8 (-9)	1.1 (-8)
			Post	0.680	0.776	0.825	2.7 (-9)	5.1 (-9)	1.1 (-8)
160° F	Irradiated	D6-7	Post	0.656	0.795	0.840	5.0 (-9)	8.8 (-9)	2.1 (-8)
		D6-8	Post	0.633	0.659	0.797	4.6 (-8)	9.9 (-8)	2.6 (-7)
		D6-9	Post	0.636	0.764	0.804	1.6 (-8)	3.1 (-8)	7.1 (-8)
		D6-10	Post	0.645	0.779	0.831	5.6 (-9)	9.1 (-9)	2.0 (-8)
	Control	D6-11	Post	0.700	0.789	0.810	6.6 (-10)	1.1 (-9)	2.6 (-9)
		D6-12	Post	0.692	0.792	0.819	4.2 (-8)	9.3 (-8)	8.4 (-7)

Test	Gamma Dose (Rads)	Neutron Exposure (n/cm^2)
100° F	4.7 (6)	4.40 (13)
160° F	2.9 (6)	9.34 (11)

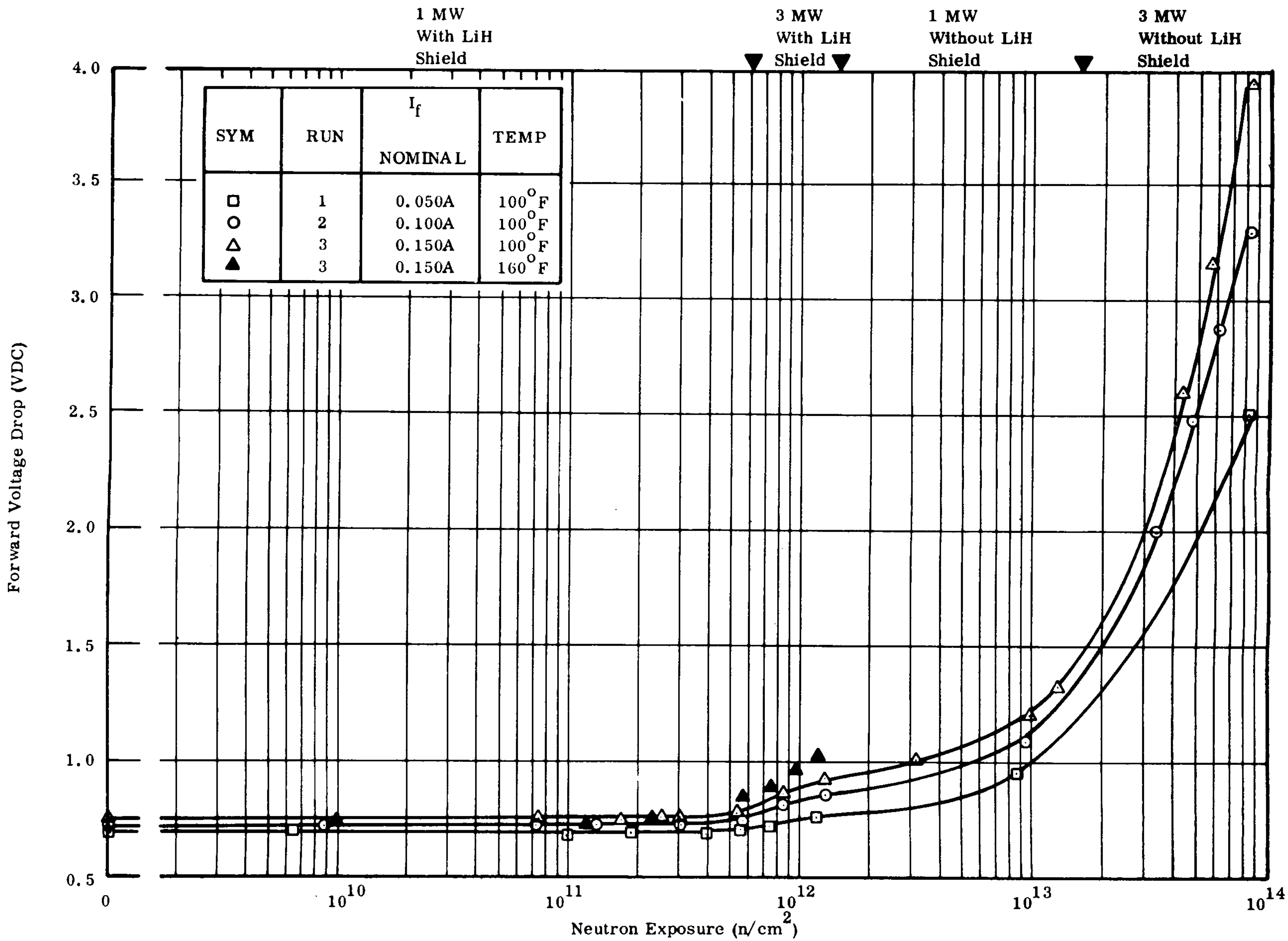


FIGURE 3-3 FORWARD VOLTAGE DROP VERSUS NEUTRON EXPOSURE, 1N547 (TYPICAL)

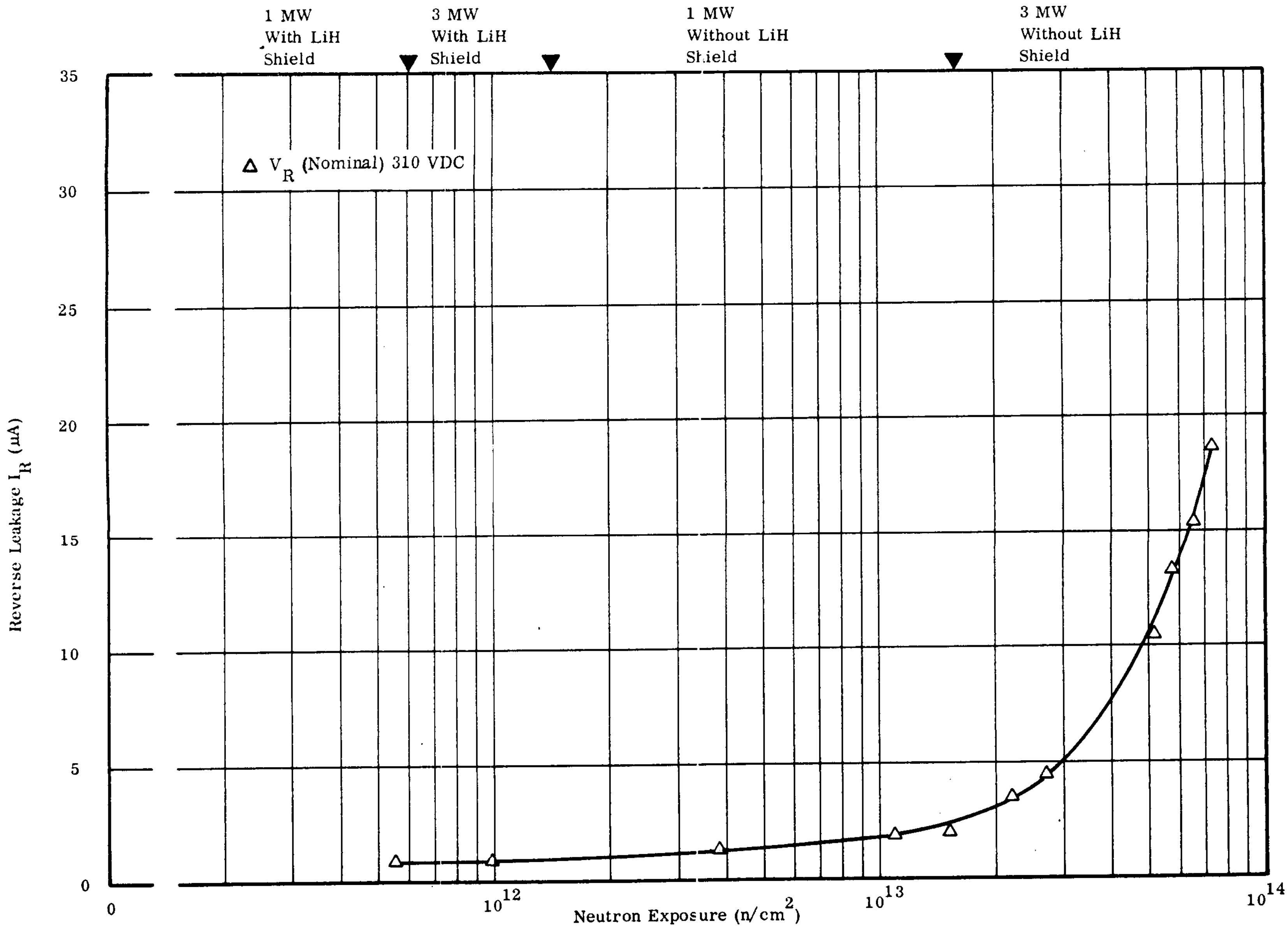


FIGURE 3-4 REVERSE LEAKAGE VERSUS NEUTRON EXPOSURE, 1N547 (TYPICAL), 100°F

TABLE 3-4 RUN 1, FORWARD VOLTAGE CHARACTERISTICS (100° F) IN547

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2 *	3	4	
0.0505	0.712	0.708	0.713	0.713	0.701	0.708	(1)
0.0507	0.699	0.693	0.701	0.700	0.684	0.693	(2)
0.0507	0.697	0.690	0.697	0.696	0.684	0.670	6.4 (9)
0.0507	0.699	0.694	0.680	0.681	0.684	0.683	9.0 (10)
0.0508	0.700	0.694	0.677	0.682	0.686	0.684	1.6 (11)
0.0507	0.702	0.690	0.684	0.689	0.690	0.695	1.9 (11)
0.0508	0.699	0.694	0.676	0.684	0.693	0.692	2.6 (11)
0.0507	0.690	0.690	0.679	0.688	0.692	0.696	3.1 (11)
0.0506	0.698	0.691	0.682	0.690	0.706	0.704	3.9 (11)
0.0507	0.690	0.684	0.680	0.694	0.715	0.714	4.8 (11)
0.0507	0.698	0.692	0.702	0.713	0.735	0.734	5.5 (11)
0.0507	0.681	0.676	0.674	0.697	0.720	0.710	6.1 (11)
0.0507	0.683	0.680	0.682	0.697	0.720	0.724	6.6 (11)
0.0507	0.691	0.692	0.720	0.730	0.764	0.766	7.5 (11)
0.0508	0.705	0.699	0.740	0.756	0.791	0.792	8.6 (11)
0.0508	0.689	0.684	0.730	0.746	0.771	0.795	1.1 (12)
0.0507	0.689	0.683	0.735	0.755	0.803	0.810	1.2 (12)
0.0507	0.681	0.681	0.750	0.769	0.820	0.829	1.3 (12)
0.0508	0.689	0.685	0.906	0.949	1.056	1.080	8.7 (12)
0.0504	0.699	0.694	2.208	2.500	3.289	3.332	8.2 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100° F

TABLE 3-5 RUN 2, FORWARD VOLTAGE CHARACTERISTICS (100° F) IN547

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2 *	3	4	
0.102	0.750	0.740	0.737	0.740	0.733	0.736	(1)
0.102	0.739	0.729	0.730	0.730	0.725	0.726	(2)
0.102	0.740	0.729	0.727	0.728	0.724	0.724	8.6 (9)
0.102	0.745	0.734	0.722	0.730	0.735	0.734	7.3 (10)
0.102	0.741	0.731	0.720	0.721	0.730	0.734	1.3 (11)
0.102	0.741	0.730	0.723	0.733	0.743	0.740	1.9 (11)
0.102	0.740	0.730	0.726	0.730	0.750	0.749	2.7 (11)
0.102	0.737	0.720	0.725	0.734	0.750	0.750	3.1 (11)
0.102	0.736	0.724	0.724	0.734	0.754	0.753	3.5 (11)
0.102	0.734	0.724	0.734	0.747	0.770	0.770	4.5 (11)
0.102	0.725	0.714	0.729	0.740	0.770	0.770	5.7 (11)
0.102	0.735	0.726	0.760	0.775	0.807	0.810	8.6 (11)
0.102	0.748	0.737	0.807	0.826	0.861	0.866	8.7 (11)
0.102	0.753	0.744	0.830	0.849	0.893	0.896	9.6 (11)
0.102	0.730	0.724	0.839	0.865	0.924	0.935	1.3 (12)
0.102	0.736	0.725	1.041	1.091	1.224	1.250	9.4 (12)
0.102	0.735	0.725	1.811	1.989	2.457	2.520	3.4 (13)
0.102	0.736	0.726	2.231	2.474	3.129	3.194	4.8 (13)
0.102	0.735	0.725	2.576	2.873	3.689	3.756	6.2 (13)
0.101	0.735	0.727	2.937	3.306	4.307	4.390	8.2 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100° F

TABLE 3-6 RUN 3, FORWARD VOLTAGE CHARACTERISTICS (100° F) IN547

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2 *	3	4	
0.153	0.773	0.762	0.755	0.759	0.754	0.756	(1)
0.154	0.764	0.750	0.748	0.750	0.746	0.748	(2)
0.154	0.769	0.754	0.741	0.751	0.759	0.757	7.5 (10)
0.154	0.763	0.750	0.740	0.748	0.760	0.758	1.7 (11)
0.154	0.763	0.750	0.744	0.755	0.773	0.770	2.5 (11)
0.154	0.760	0.749	0.750	0.760	0.780	0.776	3.0 (11)
0.153	0.761	0.741	0.754	0.764	0.785	0.785	3.5 (11)
0.153	0.757	0.740	0.758	0.774	0.799	0.790	4.4 (11)
0.153	0.750	0.740	0.770	0.783	0.814	0.813	5.4 (11)
0.153	0.760	0.749	0.805	0.820	0.859	0.860	7.3 (11)
0.153	0.764	0.749	0.820	0.847	0.893	0.896	8.7 (11)
0.153	0.760	0.747	0.855	0.879	0.920	0.938	1.0 (12)
0.153	0.760	0.740	0.870	0.896	0.959	0.965	1.1 (12)
0.153	0.760	0.745	0.891	0.925	0.995	1.005	1.3 (12)
0.153	0.765	0.750	0.991	1.001	1.120	1.131	3.2 (12)
0.154	0.752	0.748	1.140	1.200	1.350	1.300	9.9 (12)
0.153	0.760	0.746	1.248	1.325	1.510	1.554	1.3 (13)
0.154	0.762	0.743	2.380	2.638	3.336	3.415	4.3 (13)
0.153	0.760	0.746	2.850	3.173	4.060	4.150	5.7 (13)
0.153	0.764	0.750	3.488	3.940	5.099	5.221	8.2 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100° F

TABLE 3-7 RUN 3, FORWARD VOLTAGE CHARACTERISTICS (160° F) IN547

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	11	12	7	8	9	10	
0.142	0.740	0.747	0.743	0.737	0.739	0.737	(1)
0.153	0.733	0.751	0.740	0.739	0.754	0.740	1.0 (10)
0.153	0.708	0.726	0.733	0.734	0.750	0.734	1.2 (11)
0.153	0.713	0.730	0.752	0.752	0.777	0.752	2.4 (11)
0.153	0.745	0.762	0.856	0.850	0.891	0.849	5.7 (11)
0.153	0.726	0.744	0.887	0.878	0.927	0.877	7.3 (11)
0.153	0.712	0.730	0.883	0.874	0.927	0.870	7.4 (11)
0.153	0.729	0.747	0.975	0.959	1.026	0.955	9.5 (11)
0.153	0.710	0.728	1.020	0.998	1.079	0.990	1.2 (12)

(1) Pre Test at Ambient Temperature

TABLE 3-8 RUN 4, REVERSE LEAKAGE CHARACTERISTICS (100° F) IN547

Reverse Voltage (VDC)	Reverse Leakage (μA)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3	4	
263.8	0.331	0.312	0.539	0.452	0.549	0.452	3.4 (11)
263.9	0.402	0.332	0.596	0.492	0.602	0.442	3.9 (11)
264.0	0.372	0.354	0.622	0.532	0.572	0.509	4.7 (11)
263.4	0.291	0.255	0.512	0.432	0.532	0.402	5.1 (11)
263.7	0.372	0.359	0.652	0.581	0.731	0.602	5.4 (11)
263.8	0.342	0.402	0.675	0.631	0.822	0.639	6.0 (11)
263.7	0.372	0.332	0.702	0.642	0.792	0.612	7.4 (11)
263.8	0.282	0.302	0.632	0.592	0.712	0.592	8.8 (11)
263.7	0.361	0.332	0.831	0.722	0.771	0.712	1.1 (12)
263.6	0.299	0.321	1.338	1.232	1.504	1.272	1.0 (13)
263.2	0.342	0.261	8.801	8.739	10.039	10.559	8.2 (13)

TABLE 3-9 RUN 5, REVERSE LEAKAGE CHARACTERISTICS (100° F) IN547

Reverse Voltage (VDC)	Reverse Leakage (μA)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3	4	
294.3	0.301	0.312	0.481	0.452	0.582	0.499	3.8 (11)
294.4	0.342	0.302	0.572	0.511	0.611	0.389	4.0 (11)
293.8	0.322	0.301	0.519	0.472	0.572	0.503	5.1 (11)
294.2	0.362	0.412	0.639	0.601	0.822	0.608	5.4 (11)
294.2	0.442	0.412	0.771	0.612	0.801	0.642	5.8 (11)
294.1	0.412	0.352	0.812	0.619	0.832	0.672	7.0 (11)
294.0	0.369	0.332	0.772	0.604	-	0.652	9.0 (11)
294.2	0.402	0.301	0.872	0.721	0.902	-	1.0 (12)
294.2	0.402	0.348	0.932	0.772	0.972	0.782	1.1 (12)
294.1	0.302	0.352	1.411	1.351	1.672	1.421	1.1 (13)
293.8	0.309	-	9.699	9.701	13.069	11.639	8.2 (13)

TABLE 3-10 RUN 6, REVERSE LEAKAGE CHARACTERISTICS (100° F) IN547

Reverse Voltage (VDC)	Reverse Leakage (μA)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3	4	
314.0	0.481	0.432	0.801	0.672	0.801	0.712	5.6 (11)
314.0	0.312	0.348	0.822	0.742	0.912	0.772	1.0 (12)
314.0	0.412	0.349	0.901	0.838	1.012	0.801	1.1 (12)
313.9	0.431	0.308	1.101	1.002	1.201	1.001	3.9 (12)
313.9	0.402	0.392	1.702	1.511	1.801	1.502	1.2 (13)
314.0	0.342	0.358	1.804	1.601	2.099	1.701	1.5 (13)
313.9	0.441	0.412	3.112	2.821	3.512	3.042	2.2 (13)
314.0	0.381	0.402	3.911	3.632	4.552	4.021	2.7 (13)
313.9	0.442	0.362	8.209	8.352	10.479	9.112	5.2 (13)
313.9	-	0.312	10.008	10.002	13.212	11.004	5.8 (13)
313.9	0.452	0.359	11.602	11.479	15.489	13.469	6.6 (13)
314.0	0.401	0.372	13.629	13.689	18.669	16.008	7.3 (13)

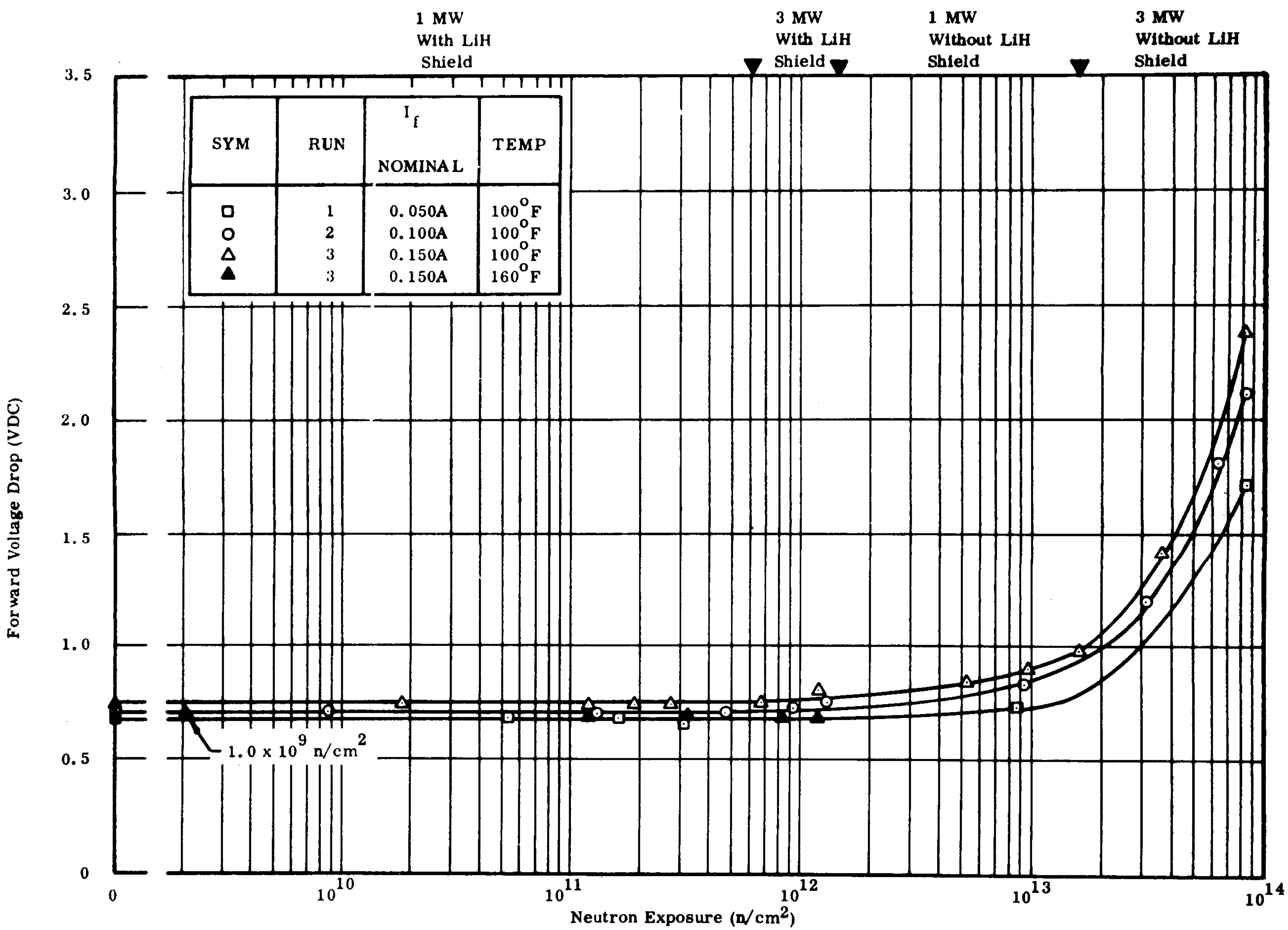


FIGURE 3-5 FORWARD VOLTAGE DROP VERSUS NEUTRON EXPOSURE, 1N2539 (TYPICAL)

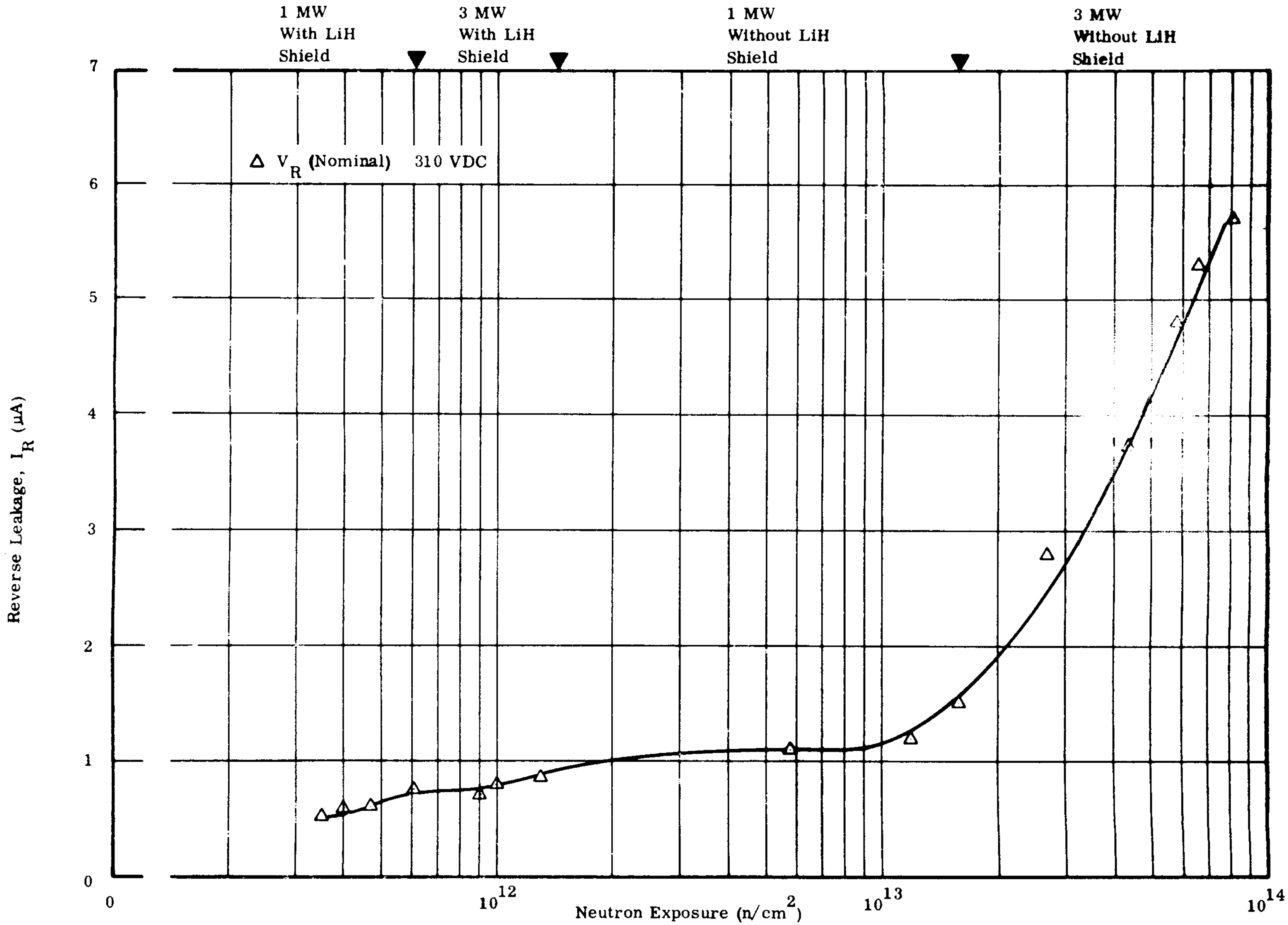


FIGURE 3-6 REVERSE LEAKAGE VERSUS NEUTRON EXPOSURE, 1N2539 (TYPICAL), 100° F

TABLE 3-11 RUN 1, FORWARD VOLTAGE CHARACTERISTICS (100° F) IN2539

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3	4 *	
0.0505	0.701	0.707	0.673	0.696	0.690	0.693	(1)
0.0507	0.688	0.691	0.660	0.683	0.676	0.680	(2)
0.0506	0.686	0.690	0.651	0.680	0.673	0.675	1.2 (10)
0.0506	0.696	0.697	0.668	0.686	0.683	0.681	5.3 (10)
0.0507	0.690	0.691	0.647	0.669	0.668	0.665	9.0 (10)
0.0505	0.690	0.693	0.659	0.670	0.675	0.660	1.3 (11)
0.0507	0.696	0.696	0.665	0.677	0.683	0.673	1.7 (11)
0.0507	0.691	0.690	0.657	0.668	0.674	0.666	1.9 (11)
0.0507	0.684	0.692	0.642	0.654	0.670	0.658	2.5 (11)
0.0508	0.691	0.691	0.653	0.664	0.671	0.663	2.7 (11)
0.0506	0.686	0.690	0.639	0.648	0.668	0.654	3.1 (11)
0.0507	0.681	0.689	0.651	0.657	0.677	0.660	3.6 (11)
0.0508	0.686	0.686	0.651	0.654	0.680	0.660	4.5 (11)
0.0508	0.681	0.681	0.646	0.648	0.679	0.656	5.5 (11)
0.0507	0.690	0.693	0.659	0.655	0.700	0.670	7.5 (11)
0.0507	0.696	0.694	0.661	0.657	0.706	0.675	8.2 (11)
0.0507	0.697	0.698	0.671	0.665	0.723	0.687	9.6 (11)
0.0508	0.674	0.680	0.630	0.625	0.691	0.655	1.1 (12)
0.0508	0.674	0.680	0.675	0.650	0.829	0.733	8.7 (12)
0.0504	0.683	0.689	1.267	1.144	2.438	1.710	8.2 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100°F

TABLE 3-12 RUN 2, FORWARD VOLTAGE CHARACTERISTICS (100° F) IN2539

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3	4 *	
0.101	0.741	0.744	0.716	0.733	0.733	0.733	(1)
1.101	0.727	0.729	0.706	0.733	0.720	0.720	(2)
0.101	0.722	0.729	0.704	0.704	0.720	0.719	8.6 (9)
0.101	0.729	0.730	0.705	0.720	0.725	0.715	7.3 (10)
0.101	0.728	0.730	0.705	0.714	0.725	0.713	1.3 (11)
0.101	0.728	0.730	0.704	0.710	0.725	0.710	1.9 (11)
0.102	0.727	0.730	0.699	0.704	0.724	0.708	2.5 (11)
0.101	0.720	0.729	0.698	0.702	0.724	0.707	3.0 (11)
0.101	0.726	0.728	0.697	0.700	0.724	0.706	3.1 (11)
0.101	0.724	0.721	0.700	0.703	0.730	0.709	3.6 (11)
0.102	0.723	0.724	0.695	0.692	0.726	0.704	4.0 (11)
0.101	0.710	0.719	0.693	0.692	0.722	0.704	4.8 (11)
0.101	0.721	0.725	0.695	0.689	0.745	0.710	7.3 (11)
0.101	0.720	0.730	0.700	0.689	0.761	0.720	9.1 (11)
0.101	0.720	0.726	0.710	0.695	0.795	0.741	1.3 (12)
0.102	0.720	0.723	0.761	0.729	0.950	0.832	9.4 (12)
0.102	0.725	0.727	0.956	0.871	1.565	1.191	3.1 (13)
0.101	0.725	0.729	1.065	0.966	1.699	1.406	4.2 (13)
0.102	0.721	0.728	1.301	1.169	2.540	1.815	6.2 (13)
0.101	0.721	0.730	1.499	1.391	3.007	2.106	8.2 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100°F

TABLE 3-13 RUN 3, FORWARD VOLTAGE CHARACTERISTICS (100° F) IN2539

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3	4	
0.152	0.765	0.769	0.745	0.760	0.765	0.760	(1)
0.153	0.752	0.755	0.737	0.749	0.753	0.749	(2)
0.153	0.750	0.754	0.734	0.748	0.749	0.745	1.8 (10)
0.153	0.750	0.755	0.735	0.744	0.756	0.744	1.2 (11)
0.153	0.751	0.750	0.738	0.741	0.759	0.740	1.9 (11)
0.153	0.750	0.757	0.735	0.738	0.764	0.744	2.7 (11)
0.153	0.750	0.750	0.734	0.734	0.761	0.744	3.8 (11)
0.153	0.742	0.740	0.728	0.724	0.760	0.731	4.8 (11)
0.153	0.742	0.745	0.734	0.727	0.777	0.745	5.1 (11)
0.153	0.750	0.755	0.735	0.725	0.785	0.750	6.9 (11)
0.153	0.754	0.758	0.743	0.732	0.800	0.761	8.6 (11)
0.153	0.750	0.754	0.745	0.724	0.818	0.769	1.0 (12)
0.153	0.749	0.754	0.750	0.733	0.827	0.779	1.1 (11)
0.153	0.755	0.759	0.773	0.755	0.856	0.800	1.2 (11)
0.153	0.750	0.754	0.785	0.755	0.936	0.840	5.2 (12)
0.153	0.750	0.755	0.809	0.749	1.024	0.896	9.9 (12)
0.153	0.750	0.756	0.860	0.806	1.155	0.971	1.6 (13)
0.153	0.755	0.759	1.107	1.003	1.928	1.429	3.6 (13)
0.153	0.750	0.750	1.456	1.290	2.964	2.001	6.4 (13)
0.152	0.753	0.756	1.659	1.400	3.437	2.377	8.2 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100° F

TABLE 3-14 RUN 3, FORWARD VOLTAGE CHARACTERISTICS (160° F) IN2539

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	11	12	7	8	9	10*	
0.152	0.735	0.743	0.761	0.733	0.740	0.728	(1)
0.152	0.704	0.709	0.720	0.702	0.703	0.697	1.0 (9)
0.152	-	0.704	0.703	0.685	0.688	0.680	1.2 (11)
0.152	0.710	0.715	0.714	0.690	0.698	0.689	3.3 (11)
0.152	0.702	0.707	0.721	0.687	0.705	0.686	7.8 (11)
0.152	0.699	0.704	0.721	0.666	0.706	0.670	1.2 (12)

(1) Pre Test at Ambient Temperature

TABLE 3-15 RUN 4, REVERSE LEAKAGE CHARACTERISTICS (100° F) IN2539

Reverse Voltage (VDC)	Reverse Leakage (μA)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3	4	
263.8	0.449	0.332	0.503	0.401	-	0.542	3.0 (11)
263.8	0.452	0.411	0.442	0.479	0.537	0.612	3.4 (11)
263.9	0.501	0.412	0.451	0.499	-	0.638	3.9 (11)
264.0	0.582	0.411	0.602	0.592	-	0.731	4.7 (11)
263.1	0.549	0.352	0.581	0.501	-	0.702	5.1 (11)
263.7	0.602	0.402	0.701	0.692	-	0.822	5.6 (11)
263.8	0.501	0.432	0.672	0.712	-	0.842	6.0 (11)
263.7	0.482	0.392	0.702	0.632	-	0.742	7.0 (11)
263.7	0.432	0.342	0.639	0.625	-	0.704	7.8 (11)
263.7	0.422	0.301	0.681	0.652	.882	0.701	1.1 (12)
263.6	0.502	0.301	1.119	0.959	1.362	1.142	1.0 (13)
263.3	0.384	0.302	3.709	3.007	4.229	3.532	8.2 (13)

TABLE 3-16 RUN 5, REVERSE LEAKAGE CHARACTERISTICS (100° F) IN2539

Reverse Voltage (VDC)	Reverse Leakage (μA)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3	4	
294.2	0.501	0.408	0.461	0.522	-	0.732	3.4 (11)
294.3	0.521	0.442	0.575	0.562	-	0.701	3.9 (11)
294.4	0.612	0.482	0.701	0.652	-	0.835	4.7 (11)
293.9	0.531	0.451	0.601	0.569	-	0.812	5.1 (11)
294.2	0.652	0.452	0.762	0.742	-	0.902	5.5 (11)
294.1	0.622	0.415	0.792	0.708	-	0.892	5.8 (11)
294.1	0.505	0.432	0.752	0.602	-	0.812	7.0 (11)
294.2	0.512	0.421	0.703	0.653	-	0.753	9.0 (11)
294.2	0.419	0.419	0.682	0.701	-	0.812	1.1 (12)
294.2	0.551	0.442	0.782	0.751	-	0.881	1.3 (12)
294.1	0.492	0.432	1.162	4.092	-	1.202	1.1 (13)
293.9	0.462	0.435	4.092	3.362	-	3.819	8.2 (13)

TABLE 3-17 RUN 6, REVERSE LEAKAGE CHARACTERISTICS (100° F) IN2539

Reverse Voltage (VDC)	Reverse Leakage (μA)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1 *	2	3	4	
314.1	0.612	0.492	0.523	0.562	-	0.709	3.5 (11)
314.2	0.641	0.502	0.602	0.582	-	0.822	4.0 (11)
314.3	0.601	0.512	0.592	0.682	-	0.901	4.7 (11)
314.0	0.643	0.472	0.765	0.802	-	1.032	6.1 (11)
314.0	0.532	0.401	0.691	0.719	-	0.801	9.0 (11)
310.1	0.521	0.442	0.831	0.787	1.232	0.902	1.0 (12)
314.0	0.602	0.462	0.844	0.792	1.242	0.912	1.1 (12)
314.1	0.522	0.388	0.859	0.813	1.061	0.931	1.3 (12)
313.9	0.512	0.412	1.102	0.929	1.262	1.132	5.8 (12)
313.9	0.512	0.442	1.201	1.173	1.572	1.392	1.2 (13)
314.0	0.502	0.442	1.492	1.342	1.802	1.522	1.6 (13)
314.0	0.552	0.442	2.801	2.305	3.201	2.672	2.7 (13)
314.0	0.512	0.432	3.742	3.101	4.431	3.632	4.4 (13)
313.9	0.602	0.442	4.802	4.012	5.602	4.669	5.8 (13)
313.9	0.512	0.412	5.312	4.458	6.211	5.122	6.6 (13)
313.9	0.501	0.301	5.704	4.762	6.712	5.472	8.1 (13)

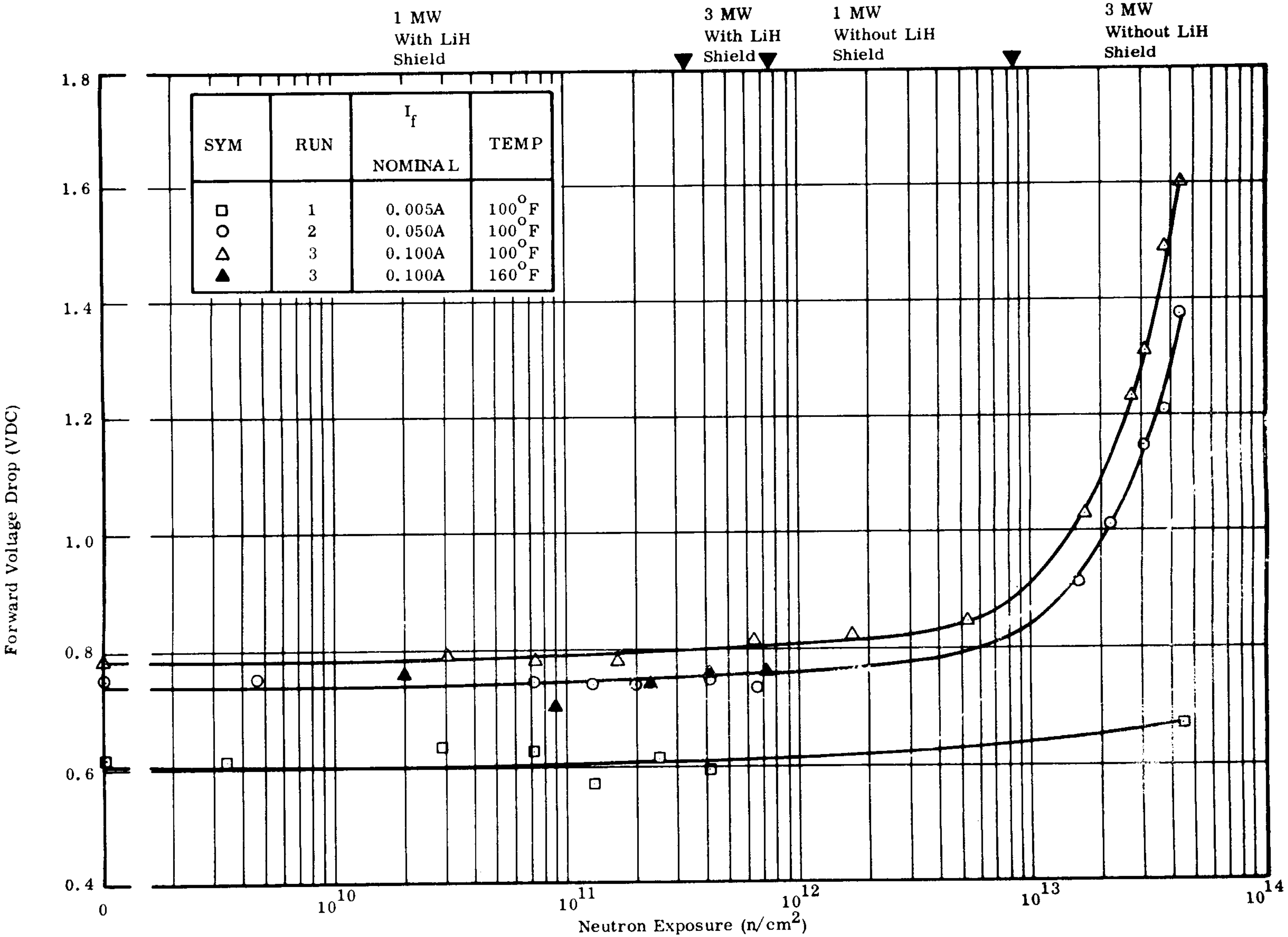


FIGURE 3-7 FORWARD VOLTAGE DROP VERSUS NEUTRON EXPOSURE, GE-90 (TYPICAL)

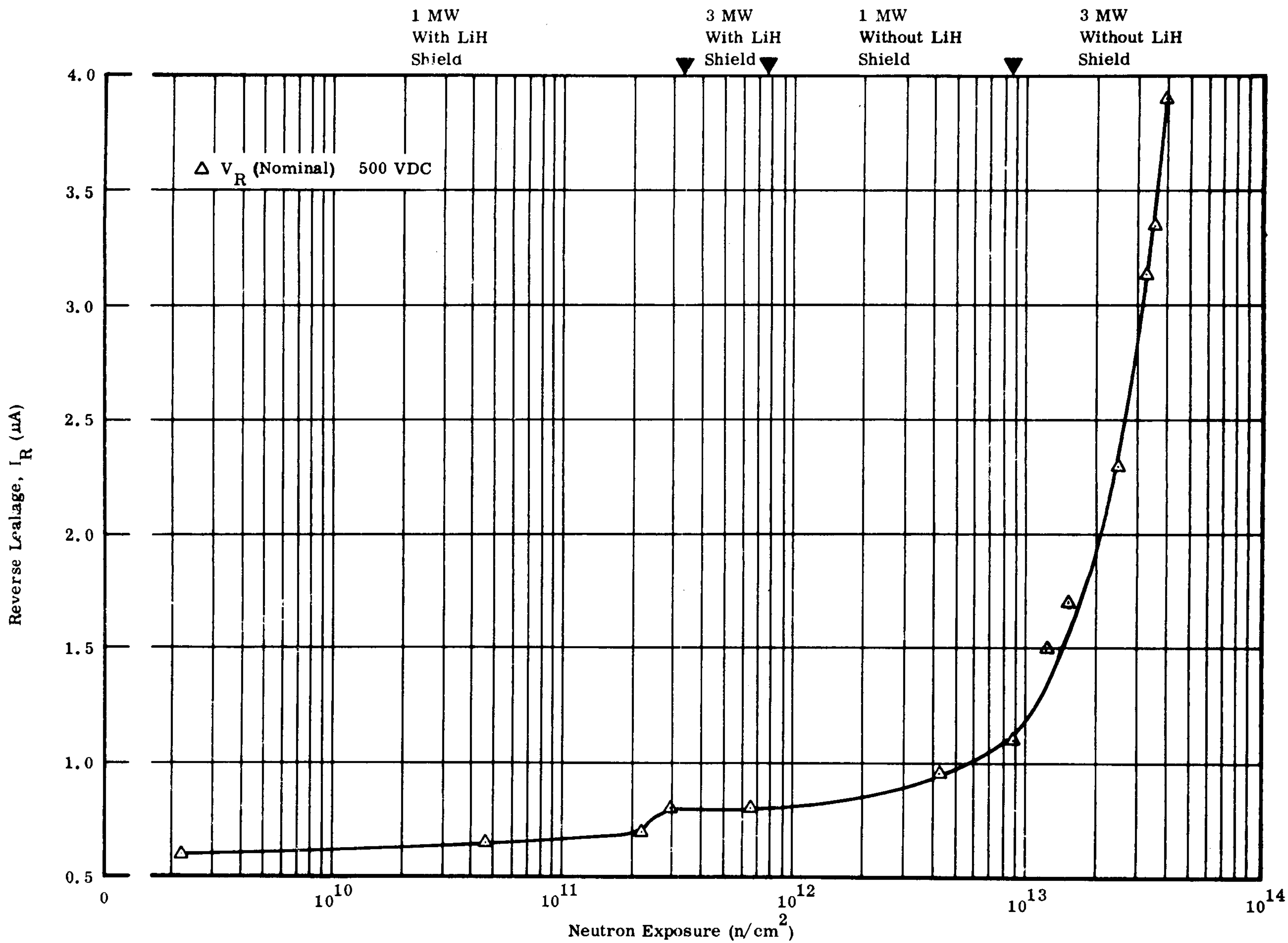


FIGURE 3-8 REVERSE LEAKAGE VERSUS NEUTRON EXPOSURE, GE-90 (TYPICAL), 100° F

TABLE 3-18 RUN 1, FORWARD VOLTAGE CHARACTERISTICS (100° F) GE-90

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1 *	2	3	4	
0.0052	0.638	0.615	0.635	0.613	0.572	0.625	(1)
0.0052	0.601	0.590	0.617	0.594	0.551	0.606	(2)
0.0052	0.615	0.584	0.611	0.581	0.544	0.599	3.4 (9)
0.0051	0.654	0.634	0.634	0.614	0.592	0.625	2.9 (10)
0.0050	0.653	0.635	0.625	0.609	0.580	0.615	7.1 (10)
0.0058	0.666	0.648	0.638	0.623	0.605	0.626	9.4 (10)
0.0052	0.621	0.593	0.571	0.558	0.520	0.551	1.3 (11)
0.0051	0.654	0.639	0.613	0.599	0.580	0.603	1.5 (11)
0.0051	0.663	0.646	0.628	0.614	0.596	0.615	1.6 (11)
0.0051	0.650	0.634	0.608	0.594	0.575	0.592	2.0 (11)
0.0052	0.623	0.590	0.562	0.547	0.510	0.540	2.1 (11)
0.0051	0.655	0.636	0.614	0.600	0.582	0.600	2.5 (11)
0.0051	0.649	0.630	0.607	0.593	0.575	0.593	2.9 (11)
0.0051	0.650	0.634	0.597	0.585	0.565	0.585	4.1 (11)
0.0050	0.657	0.639	0.606	0.594	0.574	0.590	4.4 (11)
0.0050	0.667	0.601	0.623	0.610	0.588	0.608	5.1 (11)
0.0053	0.593	0.565	0.490	0.485	0.450	0.475	5.8 (11)
0.0053	0.597	0.565	0.490	0.479	0.447	0.473	6.7 (11)
0.0053	0. -	0.562	0.496	0.485	0.445	0.475	4.7 (12)
0.0050	0.614	0.583	0.664	0.628	0.523	0.610	4.4 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100°F

TABLE 3-19 RUN 2, FORWARD VOLTAGE CHARACTERISTICS (100° F) GE-90

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1 *	2	3	4	
0.0499	0.762	0.760	0.755	0.742	0.726	0.746	(1)
0.0500	0.750	0.747	0.750	0.731	0.706	0.739	(2)
0.0500	0.750	0.740	0.749	0.734	0.701	0.738	4.6 (9)
0.0500	0.758	0.755	0.760	0.744	0.728	0.746	3.0 (10)
0.0501	0.751	0.740	0.745	0.731	0.710	0.734	7.2 (10)
0.0500	0.760	0.757	0.758	0.743	0.727	0.743	9.5 (10)
0.0501	0.751	0.740	0.740	0.730	0.710	0.728	1.3 (11)
0.0501	0.758	0.755	0.753	0.737	0.722	0.737	1.6 (11)
0.0501	0.749	0.740	0.740	0.727	0.710	0.725	2.0 (11)
0.0501	0.744	0.740	0.734	0.720	0.701	0.718	2.5 (11)
0.0501	0.735	0.730	0.719	0.704	0.680	0.701	2.9 (11)
0.0500	0.750	0.747	0.746	0.736	0.710	0.730	4.1 (11)
0.0500	0.759	0.756	0.762	0.750	0.726	0.746	4.6 (11)
0.0500	0.762	0.759	0.763	0.751	0.725	0.745	5.2 (11)
0.0500	0.740	0.737	0.736	0.719	0.694	0.715	6.8 (11)
0.0501	0.746	0.740	0.913	0.900	0.771	0.875	1.6 (13)
0.0500	0.747	0.743	1.010	0.998	0.830	0.966	2.2 (13)
0.0500	0.746	0.742	1.146	1.122	0.890	1.075	3.0 (13)
0.0500	0.746	0.742	1.146	1.122	0.890	1.075	3.0 (13)
0.0501	0.747	0.742	1.205	1.245	0.961	1.190	3.7 (13)
0.0501	0.747	0.740	1.367	1.325	1.005	1.264	4.4 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100°F

TABLE 3-20 RUN 3, FORWARD VOLTAGE CHARACTERISTICS (100° F) GE-90

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1 *	2	3	4	
0.0961	0.790	0.792	0.787	0.774	0.760	0.776	(1)
0.0964	0.771	0.780	0.782	0.767	0.751	0.760	(2)
0.0961	0.787	0.788	0.790	0.778	0.764	0.777	3.1 (10)
0.0964	0.780	0.781	0.780	0.761	0.750	0.765	7.4 (10)
0.0962	0.787	0.788	0.791	0.776	0.761	0.773	1.3 (11)
0.0964	0.779	0.783	0.780	0.760	0.750	0.764	1.7 (11)
0.0965	0.770	0.770	0.774	0.760	0.742	0.755	2.2 (11)
0.0949	0.771	0.772	0.781	0.760	0.745	0.760	3.1 (11)
0.0963	0.781	0.781	0.790	0.780	0.756	0.775	4.4 (11)
0.0965	0.776	0.776	0.791	0.776	0.745	0.770	6.1 (11)
0.0968	0.783	0.786	0.816	0.801	0.756	0.793	6.4 (11)
0.0961	0.776	0.773	0.825	0.810	0.730	0.800	1.7 (12)
0.0966	0.776	0.776	0.845	0.830	0.775	0.816	5.3 (12)
0.0967	0.776	0.770	0.919	0.900	0.815	0.885	1.1 (13)
0.0966	0.777	0.777	1.031	1.015	0.873	0.985	1.7 (13)
0.0963	0.771	0.779	1.230	1.210	0.973	1.160	2.7 (13)
0.0966	0.776	0.790	1.316	1.288	1.001	1.235	3.1 (13)
0.0958	0.777	0.776	1.491	1.404	1.105	1.387	3.8 (13)
0.0964	0.784	0.786	1.590	1.552	1.169	1.479	4.2 (13)
0.0966	0.789	0.781	1.600	1.567	1.172	1.489	4.4 (13)

(1) Pre Test At Ambient Temperature
(2) Pre Test At 100° F

TABLE 3-21 RUN 3, FORWARD VOLTAGE CHARACTERISTICS (160° F) GE-90

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	11	12	7	8	9	10*	
0.0961	0.758	0.753	0.757	0.727	0.735	0.747	(1)
0.0958	0.741	0.758	0.750	0.737	0.756	0.760	2.0 (10)
0.0956	0.740	0.740	0.724	0.710	0.710	0.700	9.1 (10)
0.0952	0.751	0.766	0.752	0.732	0.732	0.738	2.3 (11)
0.0964	0.751	0.767	0.773	0.748	0.742	0.757	4.1 (11)
0.0955	0.759	0.768	0.775	0.741	0.746	0.759	7.1 (11)

(1) Pre Test At Ambient Temperature

TABLE 3-22 RUN 4, REVERSE LEAKAGE CHARACTERISTICS (100° F) GE-90

Reverse Voltage (VDC)	Reverse Leakage (μA)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3	4	
303.0	0.242	0.229	0.212	0.212	0.222	0.232	(1)
302.9	0.242	0.262	0.232	0.282	-	0.262	(2)
303.2	0.302	0.302	0.312	0.312	0.322	0.312	3.4 (10)
303.0	0.301	0.272	0.372	0.323	-	0.252	8.2 (10)
303.0	0.359	0.201	0.329	0.322	0.357	0.241	1.6 (11)
302.8	0.482	0.282	0.331	0.372	0.472	0.312	2.9 (11)
303.0	0.302	0.282	0.332	0.341	0.352	0.312	3.1 (11)
302.9	0.326	0.302	0.382	0.342	0.359	0.301	3.9 (11)
303.0	-	0.226	0.332	0.372	0.483	0.321	5.3 (11)
303.1	-	0.215	1.302	1.131	1.302	0.901	4.4 (11)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100°F

TABLE 3-23 RUN 5, REVERSE LEAKAGE CHARACTERISTICS (100° F) GE-90

Reverse Voltage (VDC)	Reverse Leakage (μA)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3	4	
402.1	0.299	0.302	0.572	0.302	0.282	0.301	(1)
402.4	0.612	0.351	0.471	0.442	0.552	0.301	(2)
402.2	1.202	0.347	0.582	0.322	0.345	0.342	1.3 (10)
402.3	1.332	0.345	0.542	0.401	0.329	0.345	5.3 (10)
402.0	1.132	0.337	0.474	0.442	0.552	0.382	1.2 (11)
402.3	2.049	0.402	0.501	0.301	0.392	0.309	1.4 (11)
402.2	2.039	0.372	0.542	0.401	0.481	0.303	1.6 (11)
402.1	2.602	0.392	0.572	0.412	-	0.362	1.7 (11)
402.4	3.004	0.382	0.502	0.522	0.662	0.422	2.5 (11)
402.1	3.329	0.412	0.682	0.432	0.412	0.422	2.9 (11)
402.1	2.005	0.402	0.702	0.482	0.401	0.401	3.1 (11)
402.1	3.699	0.402	0.449	0.401	0.602	0.434	3.8 (11)
-	3.131	0.772	0.709	-	-	0.412	4.6 (11)
402.1	-	0.372	0.701	0.418	-	0.411	6.9 (11)
401.8	3.039	0.351	1.642	1.612	1.652	1.321	4.4 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100°F

TABLE 3-24 RUN 6, REVERSE LEAKAGE CHARACTERISTICS (100° F) GE-90

Reverse Voltage (VDC)	Reverse Leakage (μA)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2 *	3	4	
497.8	-	0.279	0.841	0.482	0.301	0.411	(1)
497.9	-	-	0.762	0.702	0.851	0.492	(2)
498.0	-	0.300	0.701	0.601	0.709	0.485	2.2 (9)
498.0	-	0.349	0.731	0.655	0.761	0.512	4.5 (10)
497.9	-	0.632	0.742	0.601	0.822	0.522	9.2 (10)
498.0	169.99	0.612	0.752	0.552	0.601	0.481	1.3 (11)
498.0	280.04	0.654	0.681	0.551	0.571	0.502	1.6 (11)
498.0	-	0.329	0.801	0.642	0.502	0.542	1.8 (11)
498.0	-	0.399	0.816	0.712	0.801	0.501	2.1 (11)
497.8	-	0.329	0.952	0.802	0.802	0.622	2.9 (11)
497.8	-	0.401	1.002	0.719	0.592	0.601	3.0 (11)
497.9	-	-	1.042	0.772	0.682	-	3.1 (11)
497.9	-	0.399	0.652	0.689	0.762	0.531	4.6 (11)
497.8	310.07	-	0.647	0.741	0.842	0.542	5.2 (11)
497.9	400.39	0.319	0.949	0.759	0.642	0.612	5.7 (11)
497.9	410.00	0.299	1.042	0.801	0.682	0.662	6.3 (11)
497.9	413.49	-	1.069	0.962	0.801	0.802	4.1 (12)
498.0	420.99	-	1.371	1.102	1.101	0.942	8.6 (12)
497.9	380.07	-	1.522	1.505	1.502	1.292	1.2 (13)
497.9	403.99	-	1.715	1.701	1.702	1.452	1.5 (13)
497.9	402.99	-	2.302	2.301	2.322	1.907	2.4 (13)
497.9	404.99	-	3.111	3.132	2.962	2.501	3.2 (13)
497.9	400.59	-	3.542	3.359	3.342	2.771	3.5 (13)
497.9	400.69	-	4.031	3.901	3.642	3.042	3.9 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100°F

3.2 SCR's

The results of the tests on the SCR's are presented by both graphical and tabular means.

Figure 3-9 shows the pre and post bench data for the forward blocking and reverse leakage characteristic of a typical SCR. This figure indicates an increase in reverse leakage from the pre-test value by a factor of 6.1 at the lowest inverse voltage to 24.5 at the highest voltage. The forward blocking current increased by a factor of 14.4 at the lowest forward voltage to 14.6 at the highest voltage. Table 3-25 includes the pre and post irradiation bench data for all SCR's subjected to the 100°F test and post irradiation data for the SCR's subjected to the 160°F test.

Figures 3-10 and 3-11 show the forward and reverse characteristics versus neutron exposure for a typical SCR. Tables 3-27 thru 3-33 include the data for all SCR's with an asterisk indicating the SCR plotted. Figure 3-10 shows a trend toward increasing voltage drop at approximately 2.5×10^{11} nvt with a steady increase from that point until the end of the test, finally reaching a value six times that for the pre-test value. It is also apparent that the slope changed noticeably when the lithium hydride shield was removed.

Figure 3-11 shows a trend toward increasing leakage current at approximately 6×1.0^{11} n/cm^2 with an increase from that point until the end of the test reaching a value 24 times the pre-test value. A noticeable increase in the slope is apparent where the lithium hydride shield was removed.

Table 3-26 includes data on the firing characteristics of five of the six SCR's tested during the 100°F test. SCR-6 was destroyed during checkout by circuit error. The SCR data for the 160°F run is omitted because the variation in the measurements is greater than any change that occurred. The SCR's were low priority items and many of the data cycles were omitted in favor of other test articles.

Prior to the beginning of the 160°F irradiation, an error was made in the wiring which destroyed four SCR's. These SCR's were replaced as follows:

SCR Originnaly to be Irradiated	Temp.	SCR Actually Used	Designation of Unit on Data
SCR-7	160°	SCR-1	SCR-7
SCR-8		SCR-2	SCR-8
SCR-9		SCR-3	SCR-9
SCR-10		SCR-4	SCR-10
SCR-11		SCR-5	SCR-11
SCR-12	160°	SCR-6	SCR-12
SCR-1	100°	SCR-7	SCR-1
SCR-2		CR 2 from SCR Control S/N 11	SCR-2
SCR-3		CR 1 from SCR Control S/N 11	SCR-3
SCR-4		SCR-10	SCR-4
SCR-5		CR 2 from SCR Control S/N 12	SCR-5
SCR-6	100°	CR 1 from SCR Control S/N 12	SCR-6

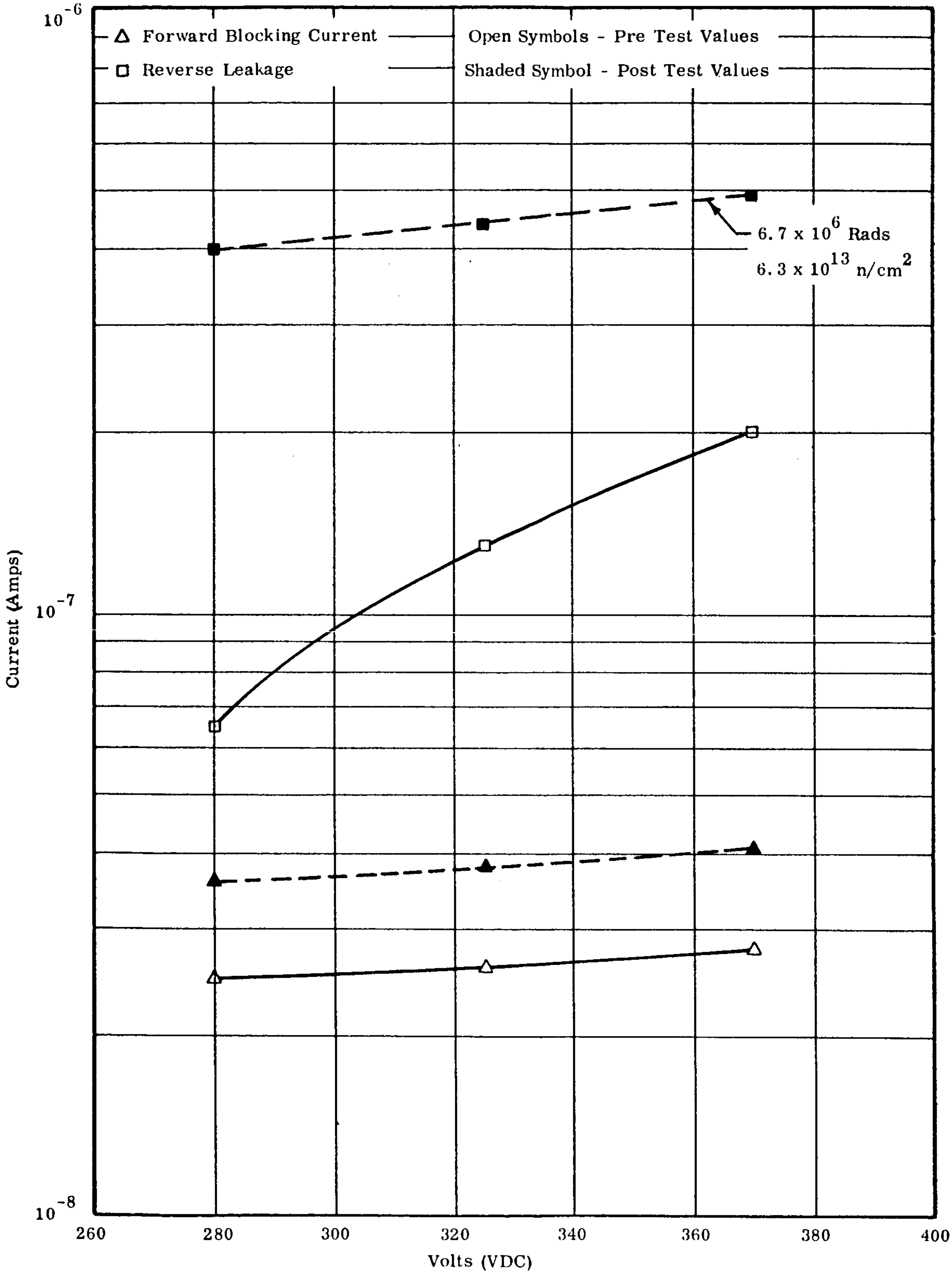


FIGURE 3-9 FORWARD AND REVERSE CHARACTERISTICS, SCR 2N1778, 100°F

TABLE 3-25 SCR CHARACTERISTICS PRE AND POST MEASUREMENT AT LABORATORY-2N1778

Test		Diode Identification	Pre or Post	I_f (Amps) @ V_f			I_R (Amps) @ V_R		
				280 VDC	325 VDC	370 VDC	280 VDC	325 VDC	370 VDC
100° F	Irradiated	SCR-1	Pre	2.5 (-8)	2.6 (-8)	2.8 (-8)	6.5 (-8)	1.3 (-7)	2.0 (-7)
			Post	3.6 (-7)	3.8 (-7)	4.1 (-7)	4.0 (-7)	4.4 (-7)	4.9 (-7)
		SCR-2	Pre	1.0 (-7)	2.5 (-7)	5.0 (-7)	3.5 (-8)	4.4 (-8)	5.7 (-8)
			Post	5.1 (-7)	6.0 (-7)	7.3 (-7)	3.6 (-7)	4.0 (-7)	4.4 (-7)
		SCR-3	Pre	3.2 (-8)	4.2 (-8)	6.5 (-8)	2.7 (-6)	6.4 (-6)	1.2 (-5)
			Post	5.5 (-7)	6.1 (-7)	6.6 (-7)	9.7 (-7)	1.6 (-6)	3.3 (-6)
		SCR-4	Pre	2.0 (-8)	2.2 (-8)	2.4 (-8)	9.0 (-7)	2.8 (-6)	1.8 (-5)
			Post	Shorted	Shorted	Shorted	Shorted	Shorted	Shorted
	Control	SCR-5	Pre	1.5 (-8)	1.6 (-8)	1.8 (-8)	1.5 (-8)	1.8 (-8)	2.3 (-8)
			Post	2.2 (-8)	2.3 (-8)	2.5 (-8)	2.4 (-8)	3.0 (-8)	3.9 (-8)
160° F	Irradiated	SCR-7	Post	1.5 (-6)	1.6 (-6)	1.7 (-6)	7.2 (-7)	2.2 (-7)	1.3 (-5)
		SCR-8	Post	1.2 (-6)	1.3 (-6)	1.4 (-6)	6.2 (-7)	6.9 (-7)	9.4 (-7)
		SCR-9	Post	8.1 (-7)	9.8 (-7)	1.2 (-6)	9.9 (-7)	1.4 (-6)	2.1 (-6)
		SCR-10	Post	3.7 (-6)	3.8 (-6)	3.7 (-6)	1.2 (-7)	1.3 (-7)	1.5 (-7)
	Control	SCR-11	Post	1.6 (-7)	2.3 (-7)	4.3 (-7)	6.0 (-5)	1.0 (-4)	1.7 (-4)
		SCR-12	Post	4.7 (-7)	5.7 (-7)	6.5 (-7)	6.8 (-8)	1.2 (-7)	1.8 (-7)

Test	Gamma Dose (Rads)	Neutron Exposure (n/cm^2)
100° F	6.7 (6)	6.3 (13)
160° F	4.1 (6)	1.13 (12)

TABLE 3-26 SCR GATE CHARACTERISTICS 100°F, 2N1778

SCR-1		
Gate Characteristics		Neutron Exposure (n/cm^2)
Gate Volts (VDC)	Gate Current (MA)	
0.6	2.0	*
0.7	1.6	1.5 (11)
1.1	4.8	2.1 (11)
1.0	5.2	3.7 (11)
1.2	4.8	6.3 (11)
1.4	4.8	6.6 (11)

SCR-2		
Gate Characteristics		Neutron Exposure (n/cm^2)
Gate Volts (VDC)	Gate Current (MA)	
0.8	4.0	*
1.0	2.4	3.6 (10)
1.1	2.4	1.5 (11)
-	5.6	2.9 (11)
1.2	7.6	3.7 (11)
1.4	5.6	6.3 (11)
1.6	7.6	6.6 (11)

SCR-5	
Gate Characteristics	
Gate Volts (VDC)	Gate Current (MA)
0.7	2.0*
0.9	1.6
-	2.8
0.8	3.6
0.7	-
0.7	3.2
0.7	2.4
1.0	3.2
1.0	3.6
.7	2.6

SCR-3		
Gate Characteristics		Neutron Exposure (n/cm^2)
Gate Volts (VDC)	Gate Current (MA)	
1.1	3.2	*
1.0	1.6	9.5 (10)
1.0	1.6	1.5 (11)
1.0	1.2	2.1 (11)
1.0	6.0	2.9 (11)
1.2	6.0	3.7 (11)
1.3	4.8	6.3 (11)
1.4	4.8	6.6 (11)

SCR-4		
Gate Characteristics		Neutron Exposure (n/cm^2)
Gate Volts (VDC)	Gate Current (MA)	
0.8	3.6	*
1.0	2.4	4.3 (10)
1.0	4.4	9.5 (10)
1.1	4.0	2.1 (11)
1.1	6.8	2.9 (11)
1.3	8.0	3.7 (11)
1.6	6.4	6.3 (11)
1.7	8.0	6.6 (11)

* Pre-Test Values

Note: Anode - Cathode Voltage set at 12 volts.

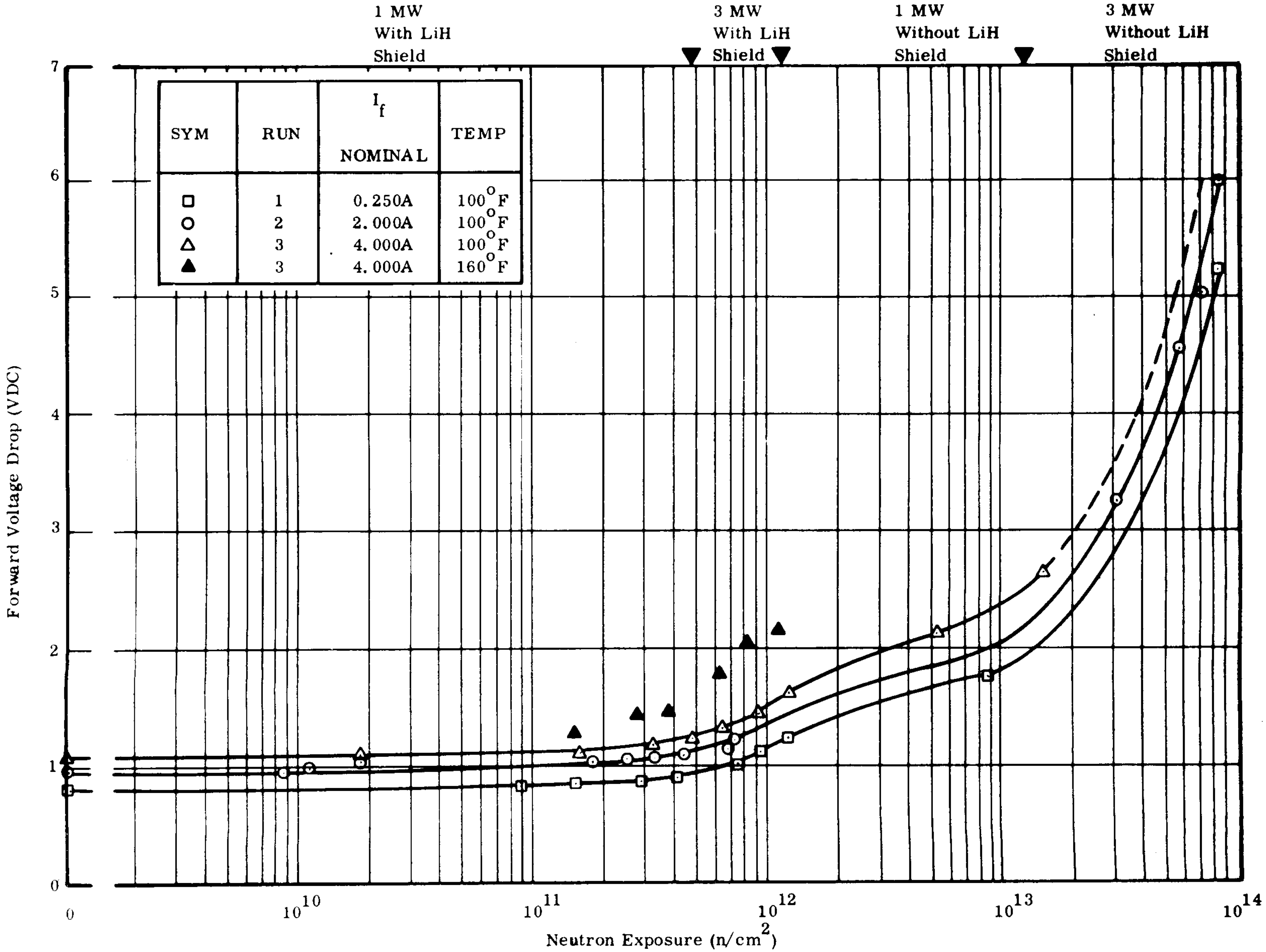


FIGURE 3-10 FORWARD VOLTAGE DROP VERSUS NEUTRON EXPOSURE, 2N1778 (TYPICAL)

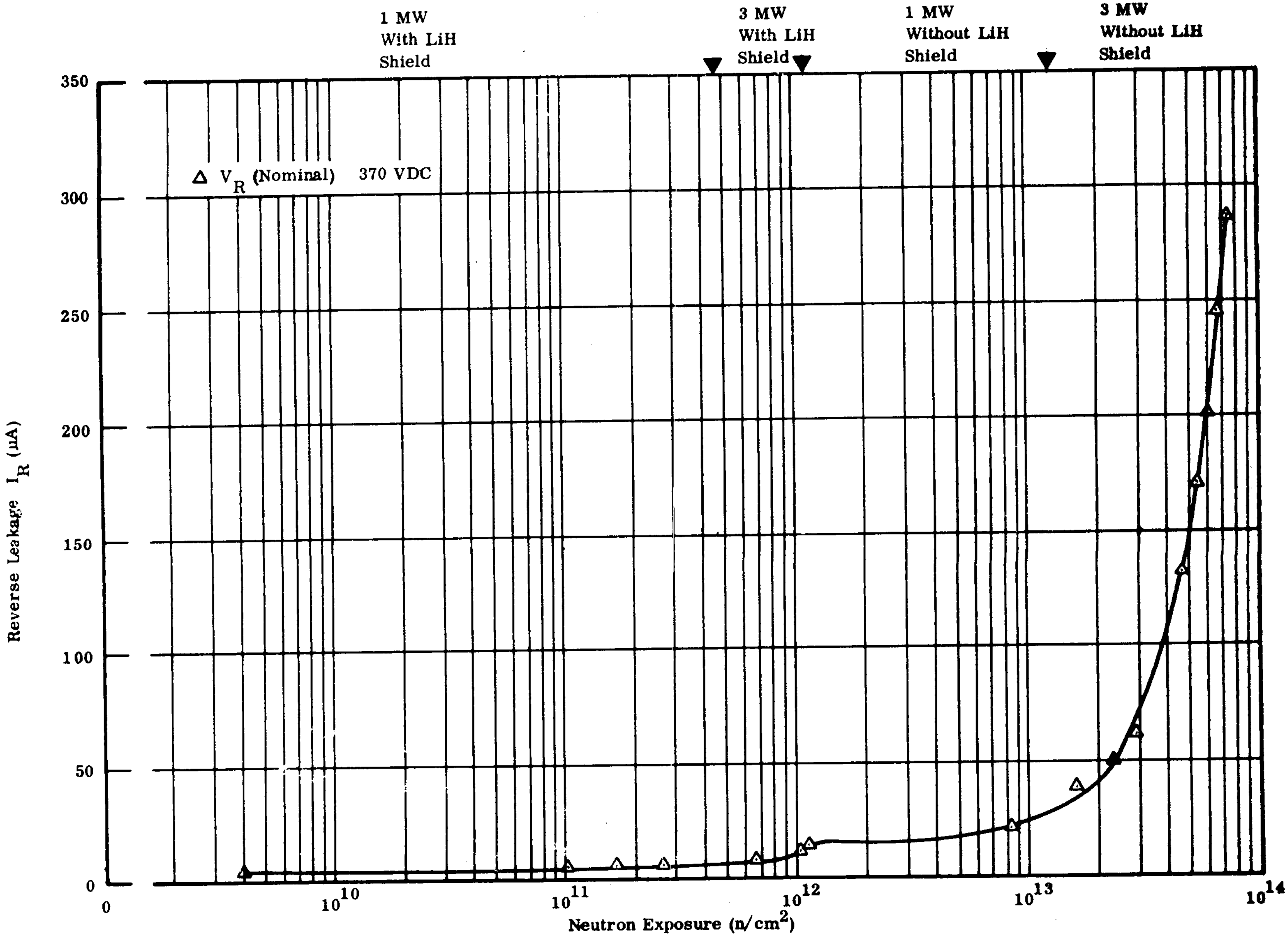


FIGURE 3-11 REVERSE LEAKAGE VERSUS NEUTRON EXPOSURE, SCR 2N1778 (TYPICAL), 100° F

TABLE 3-27 RUN 1, FORWARD VOLTAGE CHARACTERISTICS (100° F) SCR-2N1778

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control SCR's		Irradiated SCR's				
	5	6	1	2 *	3	4	
0.250	0.939	-	0.885	0.802	0.890	0.804	(1)
	-	-	0.880	0.800	0.895	-	(2)
	0.870	-	0.903	0.806	0.919	0.810	8.9 (10)
	-	-	0.910	0.814	0.920	-	1.1 (11)
	0.873	-	0.927	0.831	0.946	0.828	1.5 (11)
	0.874	-	0.941	0.848	1.013	0.841	2.3 (11)
	0.883	-	0.963	0.870	1.019	0.849	2.9 (11)
	0.874	-	0.979	0.880	1.025	0.850	3.3 (11)
	-	-	0.999	0.895	1.047	-	4.0 (11)
Nominal	-	-	1.051	0.942	1.094	-	4.6 (11)
	-	-	1.060	0.944	1.094	-	5.2 (11)
	-	-	1.063	0.947	1.100	-	5.6 (11)
	0.877	-	1.076	0.950	1.106	-	6.0 (11)
	0.870	-	1.120	1.001	1.166	1.005	6.6 (11)
	0.870	-	1.155	1.066	1.170	-	7.2 (11)
	0.891	-	1.270	1.100	1.275	-	9.1 (11)
	-	-	1.315	1.136	1.300	-	9.7 (11)
	-	-	1.431	1.230	1.380	1.230	1.2 (12)
	0.865	-	2.021	1.755	1.794	1.800	8.7 (12)
0.250	0.878	-	6.124	5.232	4.140	-	8.2 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100° F

TABLE 3-28 RUN 2, FORWARD VOLTAGE CHARACTERISTICS (100° F) SCR-2N1778

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control SCR's		Irradiated SCR's				
	5	6	1	2 *	3	4	
1.833	1.028		1.055	0.966	1.055	0.966	(1)
1.835	1.018		1.043	0.958	1.044	0.957	(2)
1.823	1.010		1.048	0.960	1.048	0.960	8.6 (9)
1.813	1.015		1.101	0.989	1.086	0.992	1.1 (10)
1.817	1.031		1.161	1.037	1.142	1.035	1.8 (11)
1.813	1.017		1.164	1.031	1.140	1.034	2.4 (11)
1.809	1.016		1.150	1.043	1.153	1.046	3.0 (11)
1.789	1.016		1.189	1.050	1.154	1.050	3.2 (11)
1.808	1.014		1.204	1.059	1.165	1.050	3.5 (11)
1.810	1.014		1.236	1.081	1.195	1.083	4.4 (11)
1.808	1.014		1.284	1.101	1.220	1.109	5.3 (11)
1.804	1.012		1.306	1.134	1.243	1.125	5.7 (11)
1.787	1.013		1.395	1.200	1.305	1.184	7.2 (11)
1.810	1.025		1.630	1.404	1.501	1.319	9.6 (11)
1.805	1.014		3.445	2.883	2.300	2.137	1.3 (12)
1.813	1.015		4.253	3.251	3.900	4.635	3.1 (13)
1.810	1.016		5.221	4.280	4.900	5.999	4.1 (13)
1.810	1.015		5.486	4.551	5.001	6.346	5.6 (13)
1.813	1.015		6.160	5.001	5.500	6.450	6.9 (13)
1.852	1.028		7.212	5.980	5.230	-	8.2 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100° F

TABLE 3-29 RUN 3, FORWARD VOLTAGE CHARACTERISTICS (100° F) SCR 2N1778

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control SCR's		Irradiated SCR's				
	5	6	1	2 *	3	4	
3.314	1.142		1.149	1.078	1.162	1.069	(1)
3.336	1.134		1.140	1.074	1.155	1.064	(2)
3.336	1.134		1.154	1.080	1.161	1.070	1.8 (10)
3.339	1.135		1.230	1.110	1.228	1.101	1.6 (11)
3.340	1.137		1.263	1.150	1.251	1.144	2.2 (11)
3.391	1.134		1.285	1.158	1.261	1.160	2.7 (11)
3.332	1.134		1.328	1.183	1.280	1.180	3.2 (11)
3.332	1.130		1.369	1.309	1.314	1.205	4.8 (11)
3.334	1.135		1.450	1.257	1.350	1.250	5.3 (11)
3.334	1.135		1.465	1.268	1.370	1.260	5.6 (11)
3.322	1.133		1.505	1.299	1.414	1.278	6.2 (11)
3.341	1.134		1.676	1.421	1.540	1.402	8.8 (11)
3.333	1.133		1.831	1.534	1.641	1.500	1.0 (12)
3.320	1.130		1.928	1.611	1.692	1.565	1.2 (12)
3.327	1.137		2.594	2.131	2.231	2.010	5.2 (12)
3.325	1.140		3.351	2.615	3.070	2.921	1.5 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100° F

TABLE 3-30 RUN 3, FORWARD VOLTAGE CHARACTERISTICS (160° F) SCR-2N1778

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control SCR's		Irradiated SCR's				
	11	12	7	8	9	10	
4.028	1.131	1.160	1.112	1.112	1.211	1.217	(1)
3.974	1.114	1.141	1.170	1.180	1.288	1.308	1.5 (11)
4.315	1.157	1.184	1.287	1.292	1.437	1.469	2.8 (11)
3.989	1.118	1.147	1.311	1.313	1.465	1.506	3.9 (11)
4.125	1.152	1.178	1.499	1.521	1.789	1.699	6.2 (11)
4.017	1.141	1.173	1.678	1.751	2.033	1.899	8.1 (11)
3.996	1.114	1.141	1.765	1.831	2.135	2.002	1.1 (12)

(1) Pre Test at Ambient Temperature

TABLE 3-31 RUN 4, REVERSE LEAKAGE CHARACTERISTICS SCR 2N1778

Reverse Voltage (VDC)	Reverse Leakage (μA)						Neutron Exposure (n/cm^2)
	Control SCR's		Irradiated SCR's				
	5	6	1	2	3	4	
284.1	-		1.409	1.119	2.006	4.989	(1)
284.4	-		3.009	3.000	3.803	9.007	1.5 (11)
284.4	.607		3.003	4.159	4.499	11.210	1.7 (11)
284.3	.269		2.999	3.649	4.449	9.469	2.2 (11)
784.5	.309		3.902	4.549	5.001	13.609	2.5 (11)
284.4	.371		3.019	4.032	5.039	13.403	3.0 (11)
284.5	-		4.009	5.007	7.029	18.002	3.4 (11)
284.5	-		4.007	5.539	7.005	18.699	4.0 (11)
284.6	.499		4.099	5.969	7.459	71.099	4.7 (11)
284.4	.330		4.039	5.002	7.502	70.079	5.5 (11)
284.3	.589		5.099	6.399	13.009	51.619	7.4 (11)
284.3	.799		5.059	8.379	15.611	63.667	9.3 (11)
284.2	-		17.460	19.039	28.639	>110.49	1.0 (13)
283.9	-		>120.00	> 87.37	74.999	F.S.	8.2 (13)

(1) Pre Test at Ambient Temperature

TABLE 3-32 RUN 5, REVERSE LEAKAGE CHARACTERISTICS (100° F) SCR 2N1778

Reverse Voltage (VDC)	Reverse Leakage (μA)						Neutron Exposure (n/cm^2)
	Control SCR's		Irradiated SCR's				
	5	6	1	2	3	4	
328.3	1.209		3.501	4.507	4.362	12.189	2.3 (10)
328.2	0.698		3.442	4.299	4.059	9.049	9.9 (10)
328.0	-		3.069	4.619	5.099	10.029	2.2 (11)
328.2	0.869		4.369	4.899	6.639	10.009	2.9 (11)
328.2	0.616		5.000	4.599	7.434	20.069	3.4 (11)
328.3	1.601		4.000	4.642	7.001	16.451	4.1 (11)
328.4	-		5.169	6.400	8.003	75.199	4.7 (11)
328.0	0.701		4.299	7.229	9.001	28.781	5.7 (11)
328.0	-		4.04	6.99	10.29	40.02	7.0 (11)
328.0	-		5.04	8.04	16.32	72.01	9.4 (11)
328.1	0.709		8.849	17.003	21.409	95.659	1.1 (12)
328.0	0.999		11.000	14.869	24.969	110.29	1.3 (12)
328.0	-		19.32	20.52	30.04	113.29	1.2 (13)
327.9	9.99		300.05	194.99	97.09	> 1000	8.2 (13)

TABLE 3-33 RUN 6, REVERSE LEAKAGE CHARACTERISTICS SCR 2N1778

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control SCR's		Irradiated SCR's				
	5	6	1	2 *	3	4	
371.9	1.209		3.339	4.089	5.409	14.209	4.0 (9)
371.9	1.099		2.999	5.005	5.089	11.302	1.0 (11)
371.8	1.029		4.007	5.000	5.007	13.099	1.6 (11)
371.9	1.639		4.562	4.549	5.619	12.507	1.9 (11)
372.0	-		5.007	5.739	7.039	18.029	2.6 (11)
371.8	0.840		5.379	6.006	8.005	21.049	3.3 (11)
371.8	0.801		6.002	7.701	9.499	30.004	5.4 (11)
371.8	0.912		5.049	7.679	9.000	28.699	5.9 (11)
371.8	-		5.99	7.19	11.29	42.00	6.5 (11)
371.8	-		5.08	8.27	10.04	50.69	7.5 (11)
371.8	-		5.59	8.20	14.01	54.05	9.0 (11)
371.9	0.699		8.001	11.779	18.099	81.909	1.0 (12)
371.8	-		9.01	13.09	72.64	104.39	1.1 (12)
371.8	-		14.32	19.19	26.28	110.04	6.5 (12)
371.7	-		17.50	20.12	29.99	128.29	8.2 (12)
371.8	-		20.01	20.09	33.89	130.01	1.3 (13)
371.8	-		20.09	37.08	45.59	171.01	1.6 (13)
371.8	-		50.01	50.69	60.99	210.03	2.3 (13)
371.8	-		74.09	60.01	74.08	193.19	2.9 (13)
371.7	-		181.99	130.03	100.01	221.19	4.7 (13)
371.8	-		240.05	170.11	191.19	243.24	5.4 (13)
371.7	-		200.59	200.03	210.04	250.99	6.0 (13)
371.7	-		370.09	243.99	260.00	290.07	6.8 (13)
371.0	-		452.99	285.99	300.08	330.32	7.5 (13)

3.3 HIGH CURRENT DIODES

Five types of diodes are discussed in this section; the GE-91. the Hughes 1N3878, the Bradley 1N2592, the Hughes 1N3888, and the GE-92. This group comprises the group of diodes with forward test currents ranging from 120 milliamperes to 9 amperes. Both graphical and tabular means are used to report the results of the tests.

Figures 3-12 and 3-13 show the pre and post irradiation bench data for forward and reverse characteristics of a typical diode for each type except the GE-92. Figures 3-14 and 3-15 show these characteristics for the GE-92. Tables 3-34 thru 3-38 include the data for all diodes with an asterisk indicating the diode plotted.

Figure 3-13 indicates an increase in the level of reverse leakage from the pre-test values. This increase is common to all types and the degree of change or increase in reverse leakage ranges from a factor of 1.13 on the 1N3888 to 14.9 on the 1N2592 at the lowest inverse voltage condition. At the highest inverse voltage the increase ranged from a factor of 1.13 on the 1N3888 to 12.9 on the 1N2539. The reverse characteristics for the GE-92 shown on Figure 3-15 also indicates this increase. The increase was by a factor of 6.9 at the lowest inverse voltage to 2.5 at the highest.

Figure 3-12 shows an increase in the level of forward voltage drop from the pre-test values. The spread of voltage drop versus forward current ranged from 152 millivolts on the 1N2595 to 380 millivolts on the 1N3878 for pre-irradiation test data. The spread ranged from 559 millivolts on the 1N2592 to 1.339 volts on the GE-91 for the post irradiation test data. The increase in the forward drop at the lower currents ranged from a factor of 1.17 on the 1N2592 to 1.81 on the GE-91. The change at the higher current ranged from a factor of 1.46 on the 1N3888 to 2.82 on the GE-91. The forward characteristics for the GE-92 shown on Figure 3-14 also indicates this increase in forward voltage drop from the pre-test value. The difference in spread of voltage drop versus forward current for the GE-92 was 114 millivolts in the pre-test data and 655 millivolts in the post-test. The increase in the forward drop at the lowest current was by a factor of 2.1 and at the highest current by a factor of 2.5.

Figures 3-16, 3-18, 3-20, 3-23 and 3-25 show forward voltage drop versus neutron exposure for the five types of diodes. Tables 3-39 thru 3-73 include the data for all diodes with an asterisk indicating the diode plotted. No significant increase in forward drop was observed until an exposure in the range of 2.5 - 5.0 x 10^{11} n/cm^2 was reached. There was a gradual increase in forward drop from the exposure level. A significant change in slope of the curve occurred when the lithium hydride shield was removed.

Figures 3-17, 3-19, 3-21, 3-24, and 3-26 show reverse leakage versus neutron exposure for the five types of diodes. Tables 3-39 thru 3-73 include the data for all diodes with an asterisk indicating the diode plotted. The graph of the 1N3888 and 1N3878 indicate definite increase in leakage currents at an exposure level of approximately 2.0 x 10^{11} n/cm^2. Closely approximating this exposure level there was a shift change where the reactor power was decreased to zero. Following startup this trend did not continue to the degree noticed prior to shift change. A slight increase in leakage started immediately after startup though it did not reach the same level until approximately 1.5 x 10^{13} n/cm^2 on the 1N3878 and 4.5 x 10^{13} n/cm^2 on the 1N3888. The temporary increase is attributed to surface ionization buildup which decayed when the irradiation ceased.

Figure 3-22 shows leakage versus gamma dose for the 1N3888. This curve shows that the first increase was primarily due to gamma irradiation produced ionization and the latter increase due to lattice damage produced by the combination of gamma and neutrons. The GE-91, 1N2592 and GE-92 showed a definite increase in leakage at an approximate exposure level of 1.0×10^{13} n/cm^2 with a slight trend from about 3.0×10^{11} to 1.0×10^{13} n/cm^2.

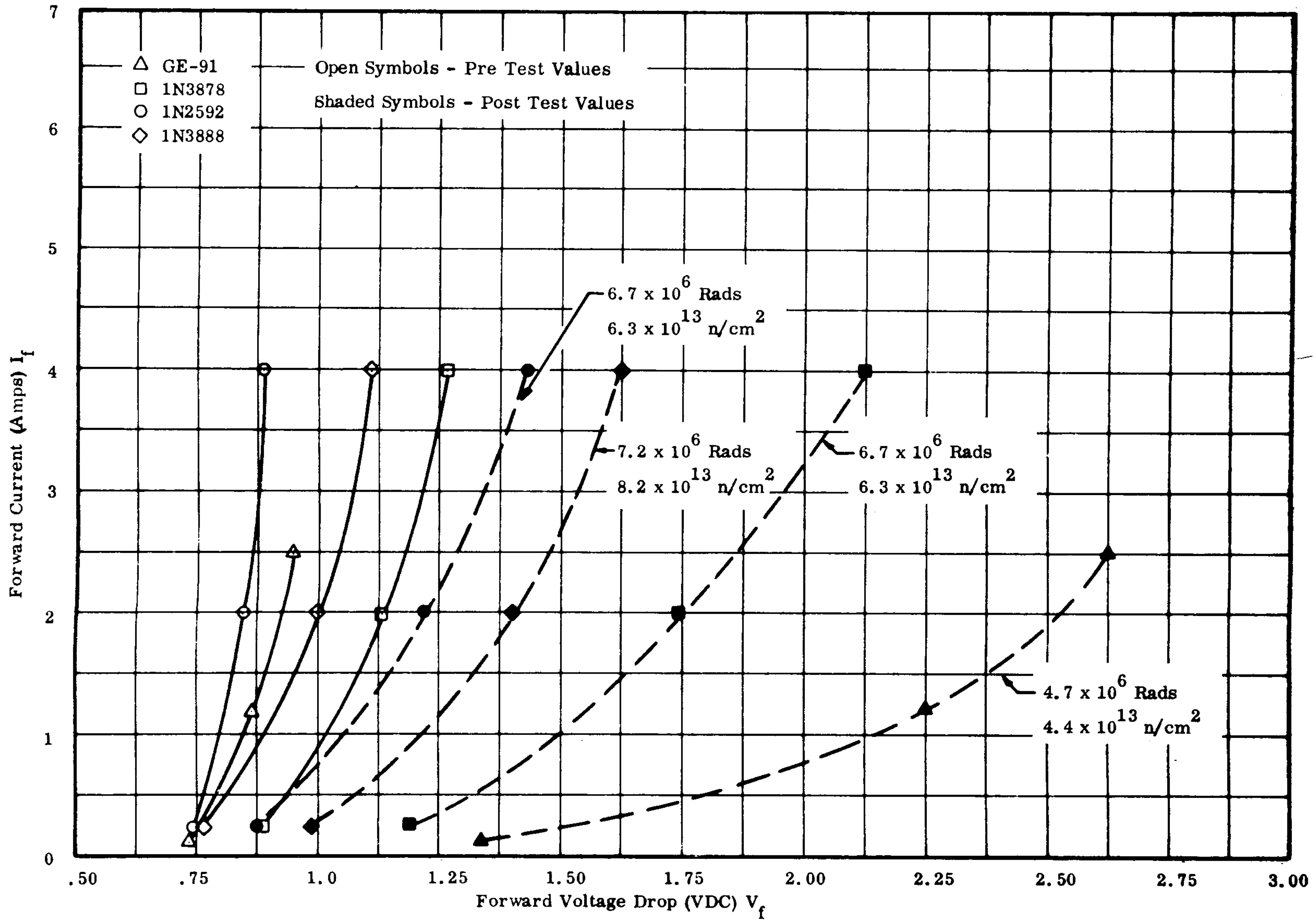


FIGURE 3-12 FORWARD CHARACTERISTICS - HIGH CURRENT DIODES - PRE AND POST MEASUREMENTS MADE AT LABORATORY, 100° F

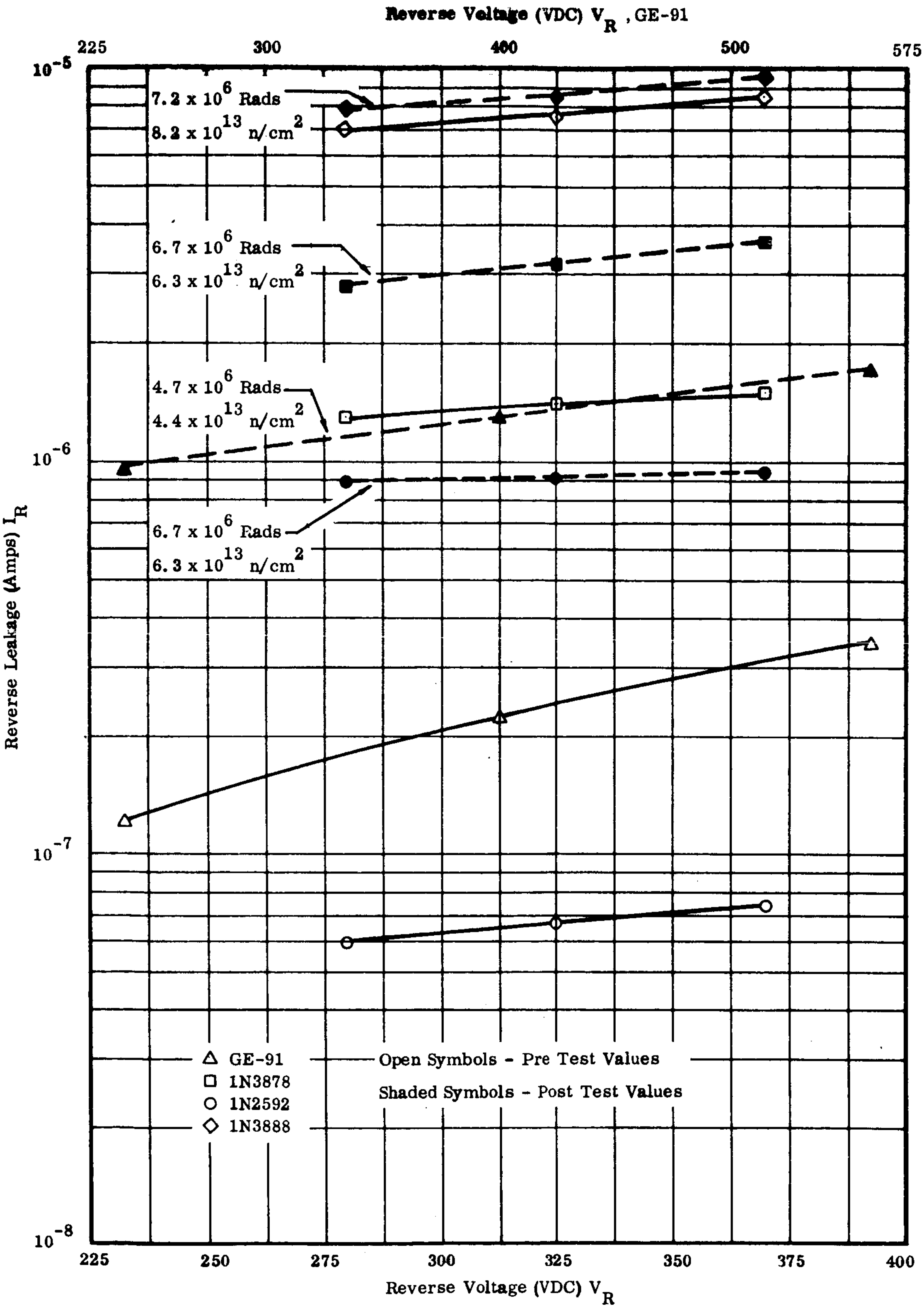


FIGURE 3-13 REVERSE CHARACTERISTICS - HIGH CURRENT DIODES - PRE AND POST MEASUREMENTS MADE AT LABORATORY, 100° F

TABLE 3-34 DIODE CHARACTERISTICS, PRE AND POST MEASUREMENTS AT LABORATORY, IN3878

Test		Diode Identification	Pre or Post	V_f at I_f 0.250A	V_f at I_f 2.000A	V_f at I_f 4.000A	I_R at V_R 280 VDC	I_R at V_R 325 VDC	I_R at V_R 370 VDC
100° F	Irradiated	D4-1	Pre	0.885	1.135	1.265	1.3 (-6)	1.4 (-6)	1.5 (-6)
			Post	1.188	1.746	2.120	2.8 (-6)	3.2 (-6)	3.6 (-6)
		D4-2	Pre	0.903	1.137	1.245	1.5 (-5)	1.7 (-5)	1.9 (-5)
			Post	1.342	1.973	2.349	5.5 (-5)	6.0 (-5)	6.2 (-5)
		D4-3	Pre	0.777	0.960	1.040	1.4 (-6)	1.5 (-6)	1.5 (-6)
			Post	0.882	1.210	1.387	2.9 (-6)	3.8 (-6)	4.7 (-6)
		D4-4	Pre	0.872	1.110	1.213	2.0 (-6)	2.5 (-6)	3.2 (-6)
			Post	1.071	1.532	1.776	2.3 (-6)	2.5 (-6)	2.7 (-6)
	Control	D4-5	Pre	0.831	1.070	1.155	8.1 (-7)	8.3 (-7)	8.5 (-7)
			Post	0.892	1.099	1.179	8.6 (-7)	8.8 (-7)	9.0 (-7)
		D4-6	Pre*	0.817	1.074	1.215	1.2 (-6)	1.3 (-6)	1.4 (-6)
			Post	0.813	1.012	1.097	1.3 (-6)	1.4 (-6)	1.5 (-6)
160° F	Irradiated	D4-7	Post	1.000	1.332	1.483	1.4 (-6)	1.6 (-6)	2.1 (-6)
		D4-8	Post	0.899	1.192	1.328	1.5 (-6)	1.6 (-6)	1.7 (-6)
		D4-9	Post	0.808	1.038	1.143	1.3 (-6)	1.4 (-6)	1.7 (-6)
		D4-10	Post	0.929	1.202	1.320	1.3 (-6)	1.4 (-6)	1.5 (-6)
	Control	D4-11	Post	0.881	1.022	1.105	2.4 (-6)	2.9 (-6)	3.5 (-6)
		D4-12	Post	0.831	1.066	1.163	1.4 (-6)	1.5 (-6)	1.6 (-6)

* Common Potential and Current Leads used in Test

Test	Gamma Dose (Rads)	Neutron Exposure (n/cm^2)
100° F	6.7 (6)	6.3 (13)
160° F	4.1 (6)	1.13 (12)

TABLE 3-35 DIODE CHARACTERISTICS, PRE AND POST MEASUREMENTS AT LABORATORY, IN3888

Test		Diode Identification	Pre or Post	V_f at I_f 0.250A	V_f at I_f 2.000A	V_f at I_f 4.000A	I_R at V_R 280 VDC	I_R at V_R 325 VDC	I_R at V_R 370 VDC
100° F	Irradiated	D1-1	Pre	0.760	1.005	1.110	7.0 (-6)	7.6 (-6)	8.5 (-6)
			Post	0.985	1.401	1.625	1.9 (-6)	8.6 (-6)	9.6 (-6)
		D1-2	Pre	0.745	0.980	1.063	3.5 (-6)	3.6 (-6)	3.8 (-6)
			Post	0.951	1.361	1.539	5.5 (-6)	5.8 (-6)	6.0 (-6)
		D1-3	Pre	0.732	0.932	1.004	3.3 (-6)	3.4 (-6)	3.6 (-6)
			Post	0.908	1.247	1.423	5.1 (-6)	5.3 (-6)	5.6 (-6)
		D1-4	Pre	0.741	0.943	1.032	2.8 (-5)	3.7 (-5)	4.5 (-5)
			Post	0.944	1.329	1.530	7.9 (-6)	8.6 (-6)	9.6 (-6)
	Control	D1-5	Pre*	0.787	1.054	1.208	4.0 (-6)	4.8 (-6)	5.9 (-6)
			Post	0.784	0.972	1.046	4.2 (-6)	4.4 (-6)	5.6 (-6)
		D1-6	Pre*	0.785	1.148	1.302	4.1 (-6)	4.6 (-6)	5.0 (-6)
			Post	0.768	0.986	1.063	4.4 (-6)	4.6 (-6)	5.0 (-6)
160° F	Irradiated	D1-7	Post	0.809	1.092	1.212	7.7 (-5)	9.7 (-5)	1.2 (-4)
		D1-8	Post	0.707	0.891	0.963	4.6 (-6)	5.0 (-6)	5.4 (-6)
		D1-9	Post	0.774	1.054	1.165	9.2 (-6)	9.6 (-6)	1.0 (-5)
		D1-10	Post	0.707	0.914	1.000	5.4 (-6)	5.8 (-6)	6.4 (-6)
	Control	D1-11	Post	0.721	0.920	0.985	4.3 (-6)	4.5 (-6)	4.6 (-6)
		D1-12	Post	0.680	0.833	0.884	3.2 (-6)	3.3 (-6)	3.5 (-6)

* Common Potential and Current Leads Used in Test

Test	Gamma Dose (Rads)	Neutron Exposure (n/cm^2)
100° F	7.2 (6)	8.2 (13)
160° F	4.4 (6)	1.3 (12)

TABLE 3-36 DIODE CHARACTERISTICS, PRE AND POST MEASUREMENTS AT LABORATORY, 1N2592

Test		Diode Identification	Pre or Post	V_f at I_f 0.250A	V_f at I_f 2.000A	V_f at I_f 4.000A	I_R at V_R 280 VDC	I_R at V_R 325 VDC	I_R at V_R 370 VDC
100° F	Irradiated	D3-1	Pre Post	0.743 0.871	0.846 1.216	0.895 1.430	5.4 (-8) 8.8 (-7)	6.6 (-8) 9.1 (-7)	7.3 (-8) 9.4 (-7)
100° F	Irradiated	D3-2	Pre Post	0.759 1.450	0.872 2.726	0.930 3.460	1.7 (-8) 2.2 (-7)	1.9 (-8) 2.4 (-7)	2.1 (-8) 2.7 (-7)
100° F	Irradiated	D3-3	Pre Post	0.745 1.33	0.845 2.22	0.886 2.93	6.1 (-8) 9.2 (-7)	7.7 (-8) 1.0 (-6)	9.5 (-8) 1.1 (-6)
100° F	Irradiated	D3-4	Pre Post	0.753 1.380	0.851 2.240	0.890 2.899	2.5 (-8) 7.9 (-7)	2.6 (-8) 8.6 (-7)	2.8 (-8) 9.2 (-7)
100° F	Control	D3-5	Pre* Post	0.853 0.776	1.090 0.886	1.202 0.935	5.1 (-9) 4.8 (-9)	5.7 (-9) 5.4 (-9)	6.3 (-9) 6.0 (-9)
100° F	Control	D3-6	Pre* Post	0.755 0.743	0.936 0.844	1.064 0.888	5.2 (-8) 3.6 (-7)	6.4 (-8) 6.0 (-7)	7.6 (-8) 7.0 (-7)
160° F	Irradiated	D3-7 D3-8	Post Post	0.806 0.757	1.030 0.939	1.148 1.028	1.7 (-7) 9.3 (-8)	1.8 (-7) 1.0 (-7)	2.0 (-7) 1.1 (-7)
160° F	Irradiated	D3-9 D3-10	Post Post	0.749 0.776	0.916 0.940	0.991 1.020	1.1 (-7) 2.9 (-7)	1.2 (-7) 3.2 (7)	1.3 (-7) 3.4 (-7)
160° F	Control	D3-11 D3-12	Post Post	0.778 0.769	0.874 0.884	0.911 0.932	1.2 (-8) 1.0 (-8)	1.6 (-8) 1.1 (-8)	2.0 (-8) 1.3 (-8)

* Common Potential and Current Leads Used in Test

Test	Gamma Dose (Rads)	Neutron Exposure (n/cm^2)
100° F	6.7 (6)	6.3 (13)
160° F	4.1 (6)	1.13 (12)

TABLE 3-37 DIODE CHARACTERISTICS, PRE AND POST MEASUREMENTS AT LABORATORY, GE-91

Test		Diode Identification	Pre or Post	V_f at I_f 0.120A	V_f at I_f 1.200A	V_f at I_f 2.500A	I_R at V_R 240 VDC	I_R at V_R 400 VDC	I_R at V_R 560 VDC
100° F	Irradiated	D7-1	Pre*	0.736	0.864	0.948	1.2 (-7)	2.2 (-7)	3.4 (-7)
			Post	1.336	2.248	2.675	9.6 (-7)	1.3 (-6)	1.7 (-6)
		D7-2	Pre*	0.728	0.878	0.974	1.2 (-7)	2.3 (-7)	3.5 (-7)
			Post	1.423	2.435	2.920	1.0 (-6)	1.4 (-6)	1.6 (-6)
		D7-3	Pre*	0.718	0.885	0.993	1.0 (-7)	3.1 (-7)	1.8 (-6)
			Post	1.166	1.817	2.104	8.7 (-7)	1.5 (-6)	2.5 (-6)
		D7-4	Pre*	0.727	0.902	1.026	3.9 (-7)	5.2 (-7)	5.9 (-7)
			Post	1.289	2.058	2.415	9.7 (-7)	1.3 (-6)	1.5 (-6)
	Control	D7-5	Pre*	0.726	0.831	0.882	1.8 (-7)	4.1 (-7)	8.1 (-7)
			Post	0.723	0.825	0.870	2.4 (-7)	4.6 (-7)	8.5 (-7)
		D7-6	Pre	0.728	0.821	0.861	8.1 (-8)	1.4 (-7)	2.3 (-7)
			Post	0.726	0.821	0.860	7.5 (-8)	1.4 (-7)	2.2 (-7)
160° F	Irradiated	D7-7	Post	0.724	0.911	0.977	3.6 (-7)	4.5 (-7)	6.0 (-7)
		D7-8	Post	0.726	0.917	0.984	3.6 (-7)	4.1 (-7)	5.0 (-7)
		D7-9	Post	0.742	0.952	1.032	6.0 (-7)	7.9 (-7)	1.1 (-6)
		D7-10	Post	0.742	0.945	1.020	3.1 (-7)	4.0 (-7)	5.4 (-7)
	Control	D7-11	Post	0.719	0.825	0.862	1.5 (-7)	2.5 (-7)	5.2 (-7)
		D7-12	Post	0.719	0.824	0.860	1.9 (-7)	3.5 (-7)	5.1 (-7)

*Common Potential and Current Leads Used in Test

Test	Gamma Dose (Rads)	Neutron Exposure (n/cm^2)
100° F	4.7 (6)	4.4 (13)
160° F	2.9 (6)	9.34 (11)

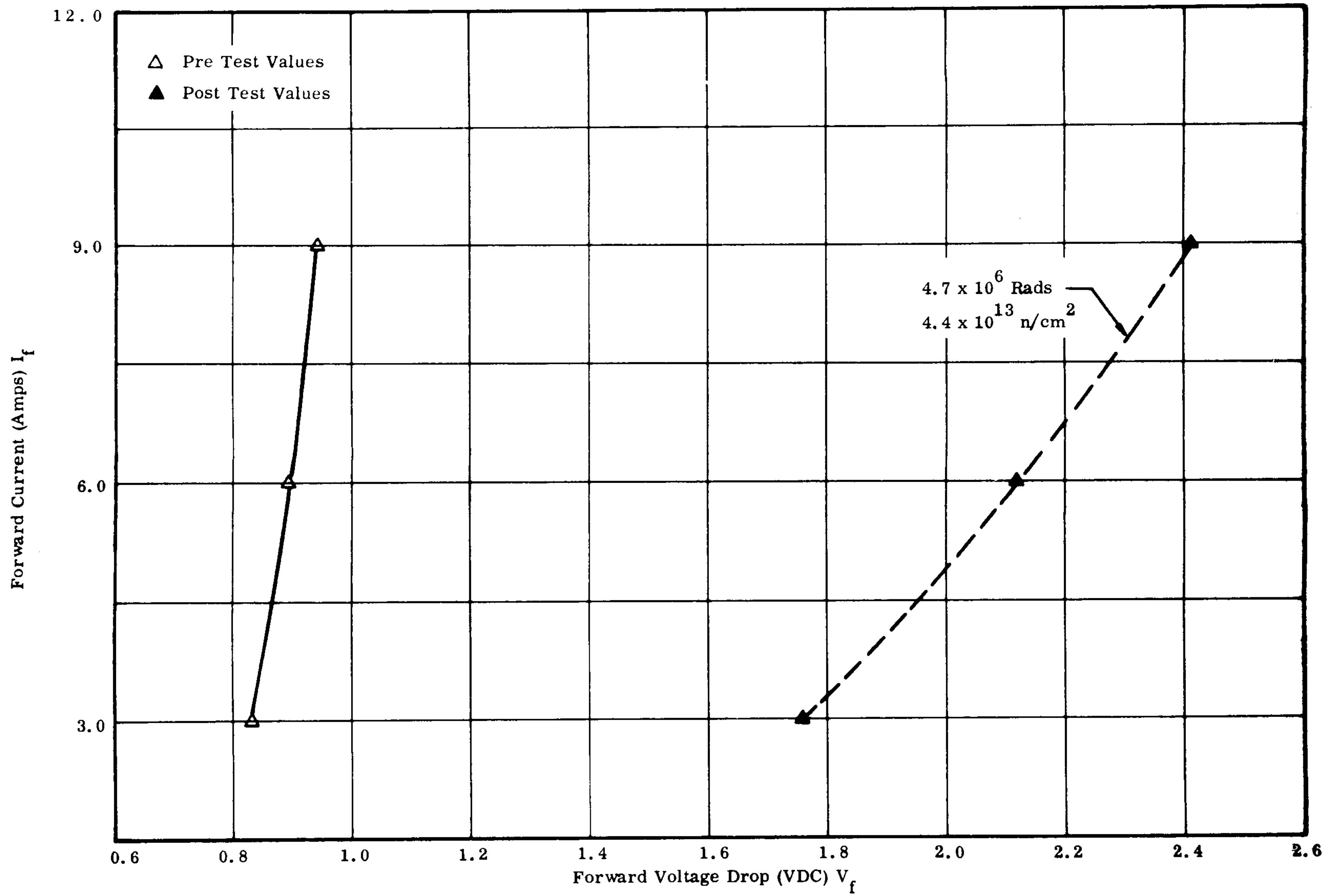


FIGURE 3-14 FORWARD CHARACTERISTICS - GE 92, 100° F - PRE AND POST MEASUREMENTS MADE AT LABORATORY

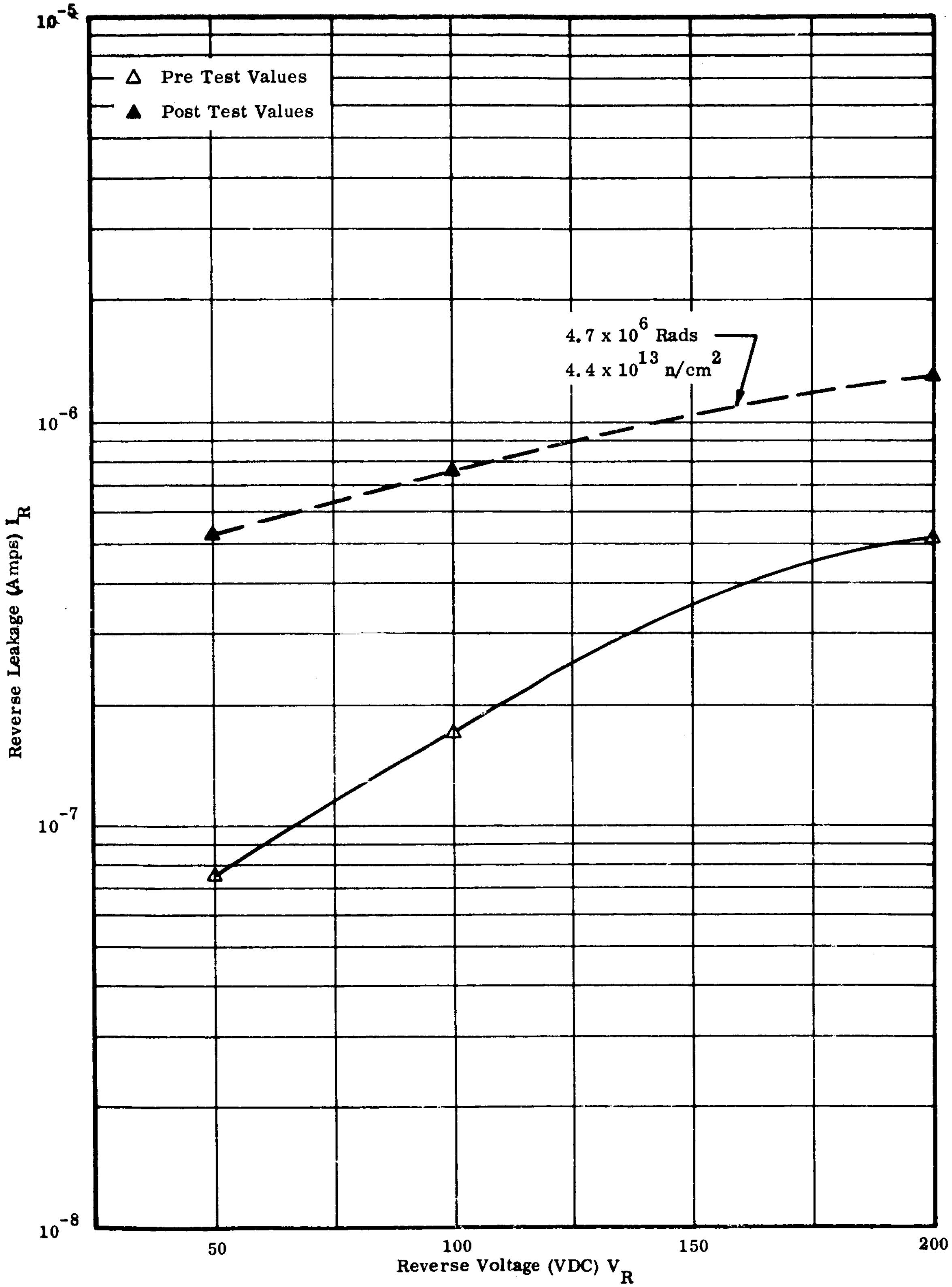


FIGURE 3-15 REVERSE CHARACTERISTICS - GE 92, 100° F - PRE AND POST MEASUREMENTS MADE AT LABORATORY

TABLE 3-38 DIODE CHARACTERISTICS, PRE AND POST MEASUREMENTS AT LABORATORY, GE-92

Test		Diode Identification	Pre or Post	V_f at I_f 3.000A	V_f at I_f 6.000A	V_f at I_f 9.000A	I_R at V_R 50 VDC	I_R at V_R 100 VDC	I_R at V_R 200 VDC
100° F	Irradiated	D8-1	Pre Post	0.832 1.755	0.894 2.115	0.946 2.410	7.6 (-8) 5.3 (-7)	1.7 (-7) 7.6 (-7)	5.2 (-7) 1.3 (-6)
		D8-2	Pre Post	0.831 1.515	0.887 1.765	0.932 1.960	9.0 (-8) 7.8 (-7)	1.2 (-7) 1.0 (-6)	2.4 (-7) 1.4 (-6)
		D8-3	Pre Post	0.814 1.520	0.864 1.760	0.900 1.965	5.2 (-8) 8.2 (-7)	9.5 (-8) 1.1 (-6)	2.3 (-7) 1.5 (-6)
		D8-4	Pre Post	0.831 1.599	0.880 1.914	0.916 2.140	5.8 (-8) 5.6 (-7)	3.8 (-7) 1.0 (-6)	2.7 (-6) 2.9 (-6)
	Control	D8-5	Pre* Post	0.906 0.823	1.037 0.880	1.160 0.922	2.5 (-7) 2.6 (-7)	4.4 (-7) 4.4 (-7)	9.9 (-7) 9.5 (-7)
		D8-6	Pre Post	0.811 0.810	0.840 0.856	0.877 0.892	1.4 (-7) 1.2 (-7)	7.5 (-7) 4.4 (-7)	5.4 (-6) 3.8 (-6)
160° F	Irradiated	D8-7 D8-8	Post Post	0.916 0.867	1.019 0.957	1.103 1.026	3.7 (-7) 5.7 (-7)	4.6 (-7) 6.7 (-7)	6.6 (-7) 1.0 (-6)
		D8-9 D8-10	Post Post	0.852 0.838	0.930 0.911	0.985 0.962	3.0 (-7) 3.8 (-7)	5.0 (-7) 4.4 (-7)	7.5 (-7) 5.8 (-7)
	Control	D8-11 D8-12	Post Post	0.819 0.816	0.870 0.866	0.907 0.900	9.2 (-8) 3.8 (-8)	1.2 (-7) 1.0 (-7)	2.3 (-7) 2.2 (-7)

* Common Potential and Current Leads Used in Test

Test	Gamma Dose (Rads)	Neutron Exposure (n/cm^2)
100° F	2.9 (6)	9.34 (11)
160° F	4.7 (6)	4.4 (13)

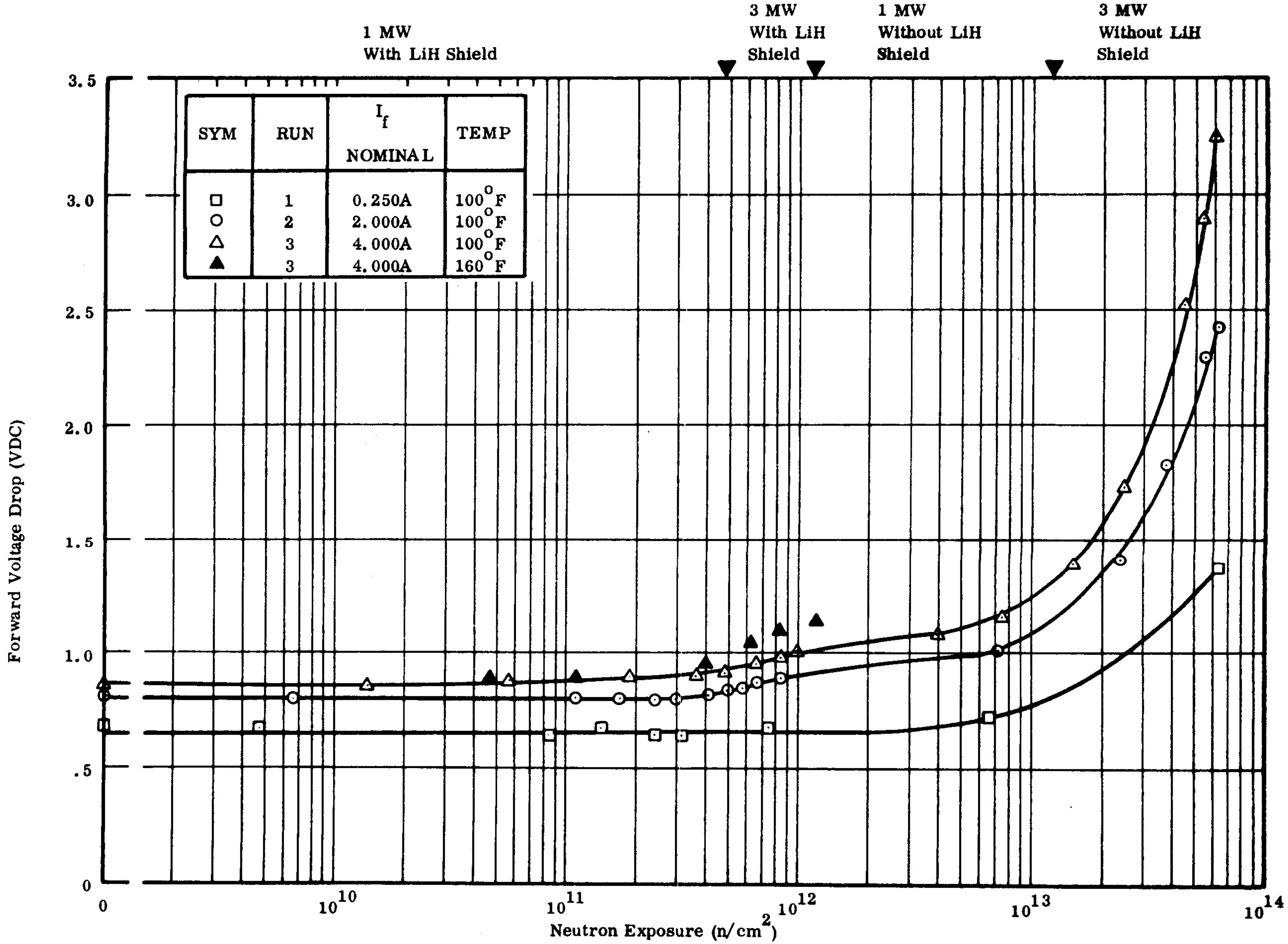


FIGURE 3-16 FORWARD VOLTAGE DROP VERSUS NEUTRON EXPOSURE, 1N2592 (TYPICAL)

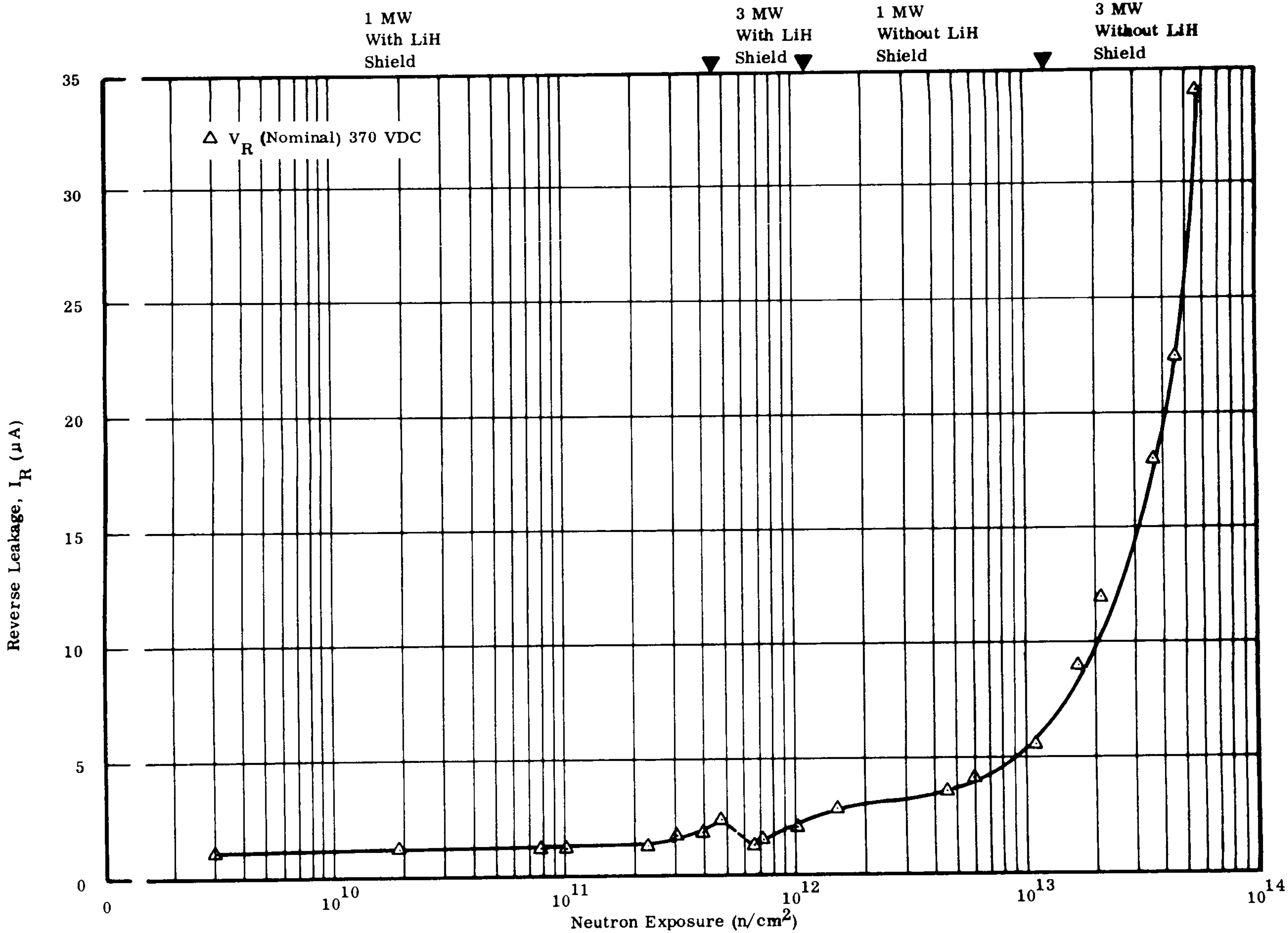


FIGURE 3-17 REVERSE LEAKAGE VERSUS NEUTRON EXPOSURE, IN2592 (TYPICAL), $100^{\circ}F$

TABLE 3-39 RUN 1, FORWARD VOLTAGE CHARACTERISTICS, IN2592

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3 *	4	
0.200	0.744	0.711	0.674	0.694	0.670	0.684	(1)
0.203	0.730	0.692	0.675	0.696	0.679	0.688	(2)
0.194	0.727	0.693	0.670	0.680	0.674	0.683	4.8 (9)
0.187	0.731	0.700	0.685	0.712	0.689	0.691	5.4 (10)
0.186	0.727	0.692	0.654	0.684	0.661	0.669	8.3 (10)
0.183	0.724	0.690	0.650	0.685	0.657	0.665	1.2 (11)
0.182	0.720	0.691	0.662	0.694	0.670	0.676	1.4 (11)
0.182	0.725	0.691	0.648	0.680	0.656	0.663	1.9 (11)
0.180	0.723	0.689	0.641	0.677	0.649	0.655	2.2 (11)
0.179	0.723	0.686	0.644	0.680	0.649	0.656	2.4 (11)
0.181	0.722	0.688	0.652	0.693	0.663	0.669	2.8 (11)
0.180	0.710	0.680	0.635	0.677	0.645	0.650	3.1 (11)
0.181	0.727	0.692	0.660	0.707	0.671	0.678	3.5 (11)
0.182	0.723	0.687	0.655	0.708	0.668	0.675	4.1 (11)
0.183	0.716	0.681	0.633	0.684	0.649	0.654	4.7 (11)
0.202	0.729	0.695	0.651	0.716	0.675	0.680	5.8 (11)
0.184	0.732	0.699	0.667	0.733	0.691	0.696	6.6 (11)
0.216	0.730	0.698	0.649	0.723	0.675	0.684	7.4 (11)
0.179	0.708	0.685	0.640	0.800	0.716	0.724	6.1 (12)
0.202	0.730	0.696	0.814	0.510	1.374	1.408	6.3 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100° F

TABLE 3-40 RUN 2, FORWARD VOLTAGE CHARACTERISTICS (100° F) 1N2592

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3 *	4	
1.867	0.869	0.831	0.810	0.850	0.813	0.815	(1)
1.866	0.851	0.821	0.800	0.840	0.804	0.806	(2)
1.860	0.857	0.823	0.800	0.840	0.803	0.806	6.6 (9)
1.856	0.860	0.824	0.810	0.854	0.816	0.818	5.6 (10)
1.857	0.850	0.822	0.800	0.850	0.809	0.810	1.1 (11)
1.856	0.855	0.821	0.800	0.850	0.810	0.813	1.7 (11)
1.857	0.858	0.821	0.798	0.860	0.813	0.814	1.9 (11)
1.849	0.854	0.820	0.800	0.869	0.800	0.800	2.4 (11)
1.847	0.854	0.814	0.798	0.873	0.800	0.806	3.0 (11)
1.860	0.852	0.816	0.798	0.880	0.819	0.820	3.5 (11)
1.856	0.840	0.810	0.796	0.888	0.820	0.825	4.1 (11)
1.863	0.855	0.820	0.805	0.901	0.835	0.836	4.8 (11)
1.851	0.856	0.822	0.815	0.928	0.852	0.855	5.8 (11)
1.873	0.862	0.828	0.831	0.950	0.871	0.872	6.6 (11)
1.867	0.856	0.821	0.824	0.976	0.880	0.880	8.4 (11)
1.859	0.855	0.820	0.865	1.182	1.011	1.013	7.2 (12)
1.834	0.851	0.800	0.959	1.805	1.414	1.408	2.4 (13)
1.841	0.855	0.820	1.055	2.356	1.830	1.820	3.7 (13)
1.835	0.855	9.820	1.175	2.855	2.305	2.282	5.3 (13)
1.861	0.857	0.823	1.238	2.880	2.430	2.403	6.3 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100° F

TABLE 3-41 RUN 3, FORWARD VOLTAGE CHARACTERISTICS (100° F) IN2592

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3 *	4	
3.814	0.932	0.902	0.886	0.930	0.885	0.884	(1)
3.808	0.915	0.883	0.860	0.910	0.860	0.860	(2)
3.787	0.914	0.884	0.860	0.913	0.860	0.860	1.4 (10)
3.783	0.915	0.885	0.869	0.921	0.874	0.870	5.7 (10)
3.786	0.915	0.884	0.869	0.935	0.876	0.871	1.1 (11)
3.769	0.913	0.883	0.864	0.944	0.890	0.872	1.9 (11)
3.770	0.912	0.880	0.867	0.955	0.885	0.880	2.6 (11)
3.774	0.900	0.875	0.865	0.973	0.890	0.889	3.6 (11)
3.786	0.911	0.880	0.879	1.000	0.914	0.910	4.8 (11)
3.790	0.918	0.886	0.905	1.056	0.952	0.940	6.6 (11)
3.767	0.910	0.880	0.902	1.087	0.965	0.960	7.7 (11)
3.775	0.910	0.881	0.905	1.105	0.970	0.970	8.4 (11)
3.774	0.910	0.881	0.915	1.145	0.996	0.995	1.0 (12)
3.768	0.912	0.881	0.949	1.280	1.085	1.080	4.0 (12)
3.778	0.911	0.881	0.966	1.390	1.155	1.100	7.6 (12)
3.764	0.911	0.881	1.026	1.762	1.387	1.310	1.5 (13)
3.775	0.915	0.880	1.103	2.280	1.725	1.704	2.2 (13)
3.778	0.910	0.881	1.287	3.242	2.520	2.475	4.4 (13)
3.781	0.910	0.881	1.400	3.651	2.950	2.891	5.4 (13)
3.776	0.920	0.890	1.462	4.094	3.262	3.166	6.0 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100° F

TABLE 3-42 RUN 3, FORWARD VOLTAGE CHARACTERISTICS (160° F) IN2592

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	11	12	7 *	8	9	10	
3.921	0.900	0.943	0.907	0.880	0.867	0.918	(1)
3.921	0.864	0.914	0.884	0.850	0.834	0.890	4.7 (10)
3.972	0.860	0.914	0.895	0.862	0.802	0.893	1.1 (11)
4.103	0.860	0.921	0.963	0.905	0.877	0.930	3.9 (11)
3.998	0.867	0.918	1.037	0.945	0.912	0.959	6.2 (11)
4.004	0.873	0.920	1.100	0.976	0.942	0.984	8.1 (11)
3.867	0.858	0.900	1.130	0.984	-	0.989	1.1 (12)

(1) Pre Test at Ambient Temperature

TABLE 3-43 RUN 4, REVERSE LEAKAGE CHARACTERISTICS (100°F) 1N2592

Reverse Voltage (VDC)	Reverse Leakage (μA)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3	4	
285.0	0.412	0.999	1.012	0.579	0.912	0.601	(2)
285.2	0.431	13.25	1.261	0.497	0.652	0.612	9.2 (9)
285.1	0.412	13.02	0.608	0.552	0.922	3.001	1.6 (10)
285.0	0.412	4.899	1.102	0.552	0.928	26.012	5.9 (10)
284.9	0.402	10.598	1.181	0.586	1.012	33.319	1.1 (11)
284.9	0.402	13.869	1.212	0.592	1.043	40.099	1.5 (11)
285.1	0.432	10.399	0.821	0.609	1.102	50.007	2.0 (11)
285.0	0.411	5.169	1.407	0.549	1.041	24.429	2.3 (11)
285.0	0.412	5.029	1.412	0.712	1.079	42.611	2.6 (11)
285.0	0.447	4.009	1.402	0.752	1.347	43.852	3.0 (11)
285.1	0.461	5.222	1.607	0.892	1.504	37.799	3.4 (11)
284.9	0.442	6.099	1.605	0.999	1.801	44.379	4.1 (11)
284.9	0.412	5.412	1.442	0.942	1.672	35.302	5.4 (11)
285.0	0.402	3.663	1.021	0.662	1.101	5.001	6.6 (11)
284.9	0.301	5.362	2.091	1.092	1.801	16.512	7.6 (11)
284.9	0.411	5.699	2.301	1.222	2.049	26.099	8.4 (11)
284.8	0.482	4.429	2.388	1.325	2.267	23.049	1.0 (12)
284.8	0.412	5.812	3.882	2.209	3.801	19.229	7.7 (12)
284.5	0.331	5.229	20.002	16.009	24.199	70.019	6.3 (13)

(2) Pre Test at 100° F

TABLE 3-44 RUN 5, REVERSE LEAKAGE CHARACTERISTICS(100°F) 1N2592

Reverse Voltage (VDC)	Reverse Leakage (μA)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3	4	
328.3	0.534	6.006	.722	0.621	1.042	20.029	1.8 (10)
328.2	0.401	12.401	1.012	0.641	1.132	107.99	9.2 (10)
328.1	0.502	10.009	1.332	0.695	1.242	140.74	1.1 (11)
328.1	0.472	8.005	1.101	0.652	1.108	100.07	1.4 (11)
328.2	0.482	6.299	0.652	0.529	1.049	168.00	2.1 (11)
328.1	0.502	11.019	1.039	0.701	1.338	100.89	2.4 (11)
328.1	0.390	11.07	1.519	0.749	1.452	150.29	2.8 (11)
328.3	0.219	9.112	1.262	0.892	1.722	133.99	3.4 (11)
328.1	0.599	8.99	2.142	1.089	2.002	100.09	4.1 (11)
328.0	0.602	10.532	1.844	1.151	2.108	122.99	4.6 (11)
328.0	-	-	-	-	-	105.99	5.4 (11)
328.1	0.511	20.239	1.222	0.621	1.002	37.399	6.6 (11)
328.1	0.471	14.999	2.201	1.252	2.072	73.999	7.7 (11)
328.0	0.532	9.079	2.008	1.362	2.312	80.001	8.4 (11)
328.1	0.546	8.342	2.672	1.541	2.542	80.599	1.0 (12)
328.0	0.542	7.629	3.992	2.628	4.301	70.004	8.4 (12)
327.8	-	-	-	-	-	50.08	9.2 (12)
327.8	-	-	-	10.89	20.29	20.03	6.3 (13)

TABLE 3-45 RUN 6, REVERSE LEAKAGE CHARACTERISTICS (100°F) 1N2592

Reverse Voltage (VDC)	Reverse Leakage (μA)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3 *	4	
371.8	0.572	9.019	1.362	0.712	1.172	0.901	3.1 (9)
371.8	0.612	2.999	1.002	0.712	1.242	-	1.9 (10)
371.8	0.539	10.007	1.402	0.742	1.302	200.07	7.7 (10)
371.7	0.571	25.799	0.802	0.672	1.242	342.99	1.0 (11)
371.6	0.601	16.329	1.241	0.771	1.442	329.59	1.8 (11)
371.7	0.601	7.799	1.175	0.701	1.301	244.00	2.3 (11)
371.6	-	14.899	0.998	0.812	1.641	314.19	2.8 (11)
371.8	-	9.469	1.002	0.892	1.672	316.99	3.1 (11)
371.5	-	10.004	1.502	0.928	1.811	300.09	3.9 (11)
371.6	0.499	12.631	2.053	1.262	2.452	200.04	4.7 (11)
371.7	0.602	9.602	1.102	0.711	1.286	200.07	6.6 (11)
371.6	-	13.439	1.502	0.882	1.612	100.06	7.4 (11)
370.2	0.541	3.372	1.462	1.002	1.942	226.99	9.2 (11)
370.2	0.552	3.427	1.802	1.104	2.052	59.999	1.0 (12)
371.5	0.622	12.069	2.702	1.601	2.832	139.99	1.5 (12)
371.5	0.639	12.069	2.781	1.831	3.042	100.00	3.0 (12)
371.6	0.322	10.499	3.342	2.149	3.602	100.03	4.5 (12)
371.6	0.301	13.199	3.912	2.399	4.072	100.79	5.8 (12)
371.6	0.601	12.799	4.332	2.862	5.042	130.05	9.2 (12)
371.6	0.602	13.005	-	3.399	5.602	110.01	1.1 (13)
371.6	0.549	13.001	7.723	5.792	9.049	142.99	1.1 (13)
371.6	3.099	12.402	9.602	7.631	12.032	-	2.1 (13)
371.6	-	12.44	10.59	13.99	17.99	191.00	3.6 (13)
371.6	0.582	13.372	20.019	22.552	30.141	181.39	4.5 (13)
371.6	-	12.679	32.069	34.132	43.001	170.69	5.6 (13)

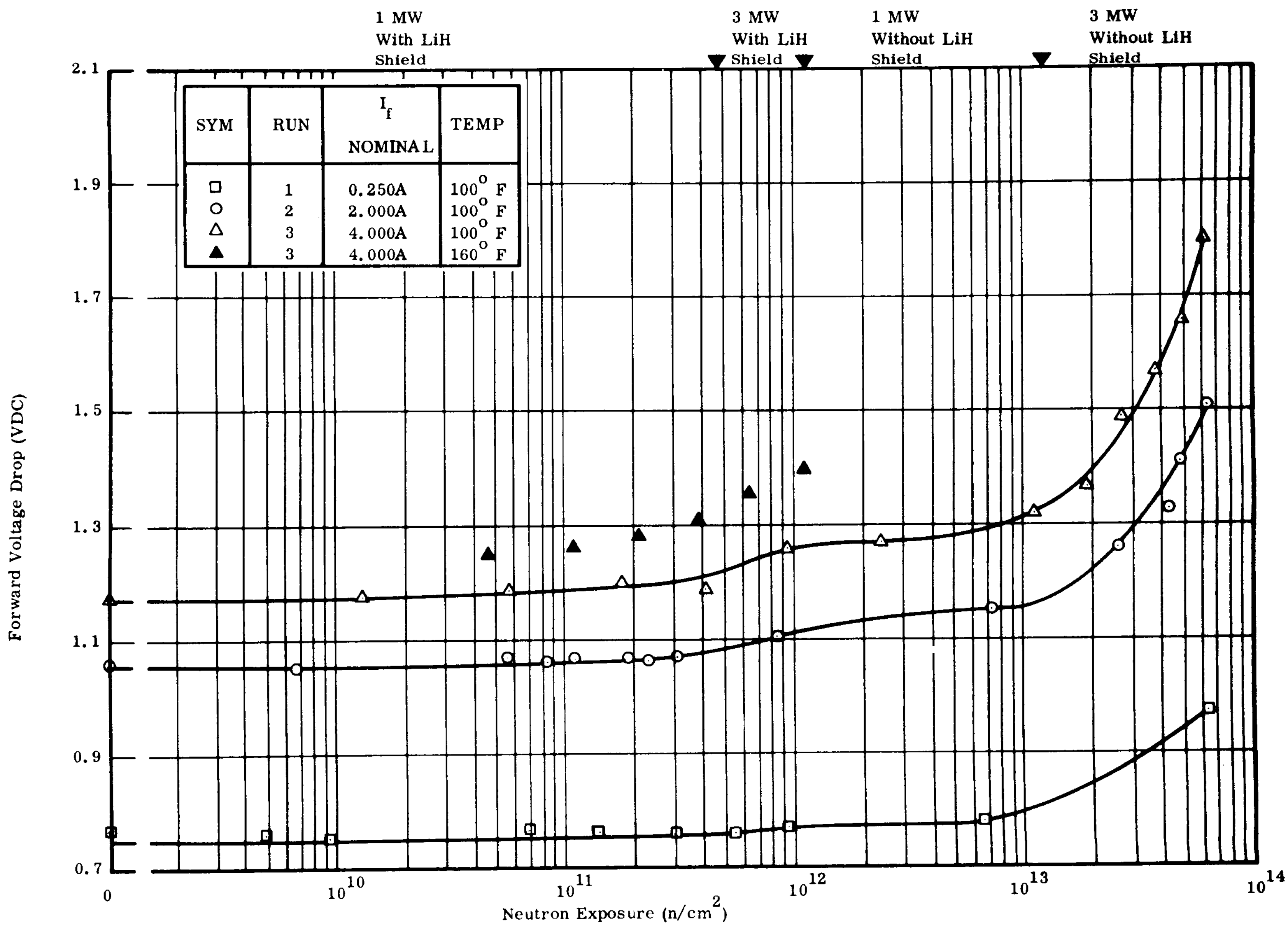


FIGURE 3-18 FORWARD VOLTAGE DROP VERSUS NEUTRON EXPOSURE, 1N3878 (TYPICAL)

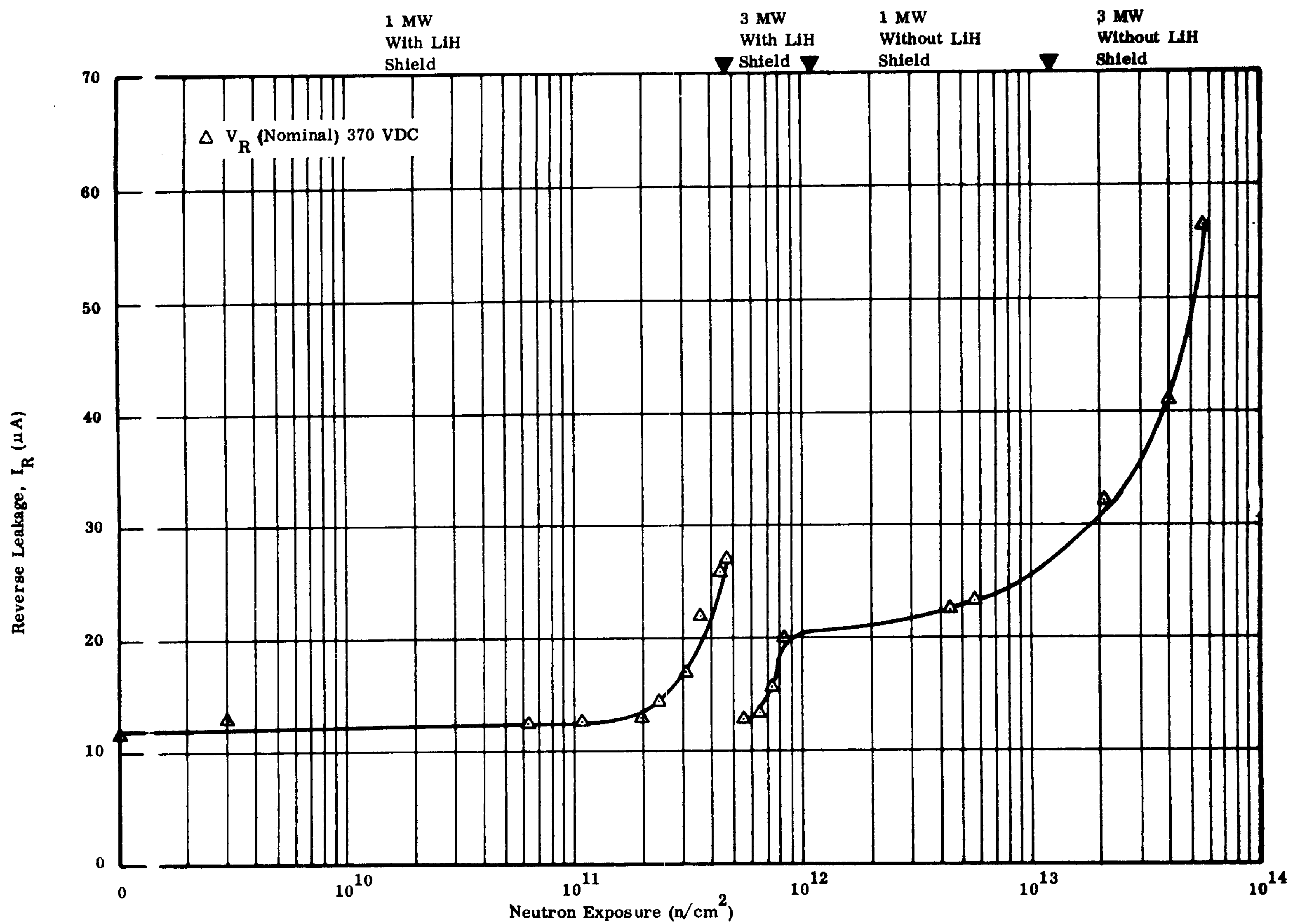


FIGURE 3-19 REVERSE LEAKAGE VERSUS NEUTRON EXPOSURE, 1N3878 (TYPICAL), 100° F

TABLE 3-46 RUN 1, FORWARD VOLTAGE CHARACTERISTICS (100° F), IN3878

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3	4 *	
0.202	0.818	0.759	0.797	0.807	0.706	0.782	(1)
0.205	0.790	0.738	0.784	0.790	0.695	0.769	(2)
0.196	0.784	0.733	0.777	0.783	0.690	0.762	4.9 (9)
0.191	0.780	0.730	0.774	0.781	0.687	0.755	9.2 (9)
0.185	0.770	0.728	0.772	0.772	0.680	0.756	6.9 (10)
0.191	0.783	0.730	0.777	0.784	0.690	0.762	1.1 (11)
0.183	0.780	0.730	0.780	0.785	0.694	0.765	1.4 (11)
0.192	0.780	0.730	0.779	0.785	0.680	0.764	1.6 (11)
0.184	0.778	0.720	0.774	0.780	0.684	0.758	1.9 (11)
0.182	0.775	0.725	0.774	0.780	0.684	0.754	2.4 (11)
0.195	0.778	0.729	0.780	0.785	0.678	0.760	3.0 (11)
0.191	0.765	0.720	0.776	0.779	0.670	0.754	3.1 (11)
0.180	0.742	0.700	0.761	0.764	0.670	0.740	5.1 (11)
0.195	0.754	0.711	0.764	0.764	0.689	0.740	4.6 (11)
0.181	0.771	0.724	0.767	0.790	0.685	0.760	5.5 (11)
0.189	0.782	0.730	0.790	0.798	0.693	0.769	6.6 (11)
0.218	0.797	0.746	0.810	0.820	0.705	0.780	7.4 (11)
0.196	0.780	0.730	0.805	0.811	0.695	0.774	9.2 (11)
0.180	0.770	0.726	0.819	0.837	0.695	0.780	6.1 (12)
0.204	0.791	0.740	1.105	1.244	0.800	0.973	6.3 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100° F

TABLE 3-47 RUN 2, FORWARD VOLTAGE CHARACTERISTICS (100° F) IN3878

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3	4 *	
1.879	1.070	0.998	1.098	1.104	0.929	1.074	(1)
1.867	1.057	0.986	1.085	1.091	0.915	1.058	(2)
1.861	1.051	0.981	1.084	1.090	0.915	1.050	6.6 (9)
1.857	1.060	0.988	1.095	1.104	0.924	1.070	5.6 (10)
1.858	1.059	0.984	1.091	1.098	0.916	1.061	8.4 (10)
1.858	1.051	0.980	1.094	1.100	0.907	1.064	1.1 (11)
1.857	1.055	0.984	1.099	1.108	0.920	1.064	1.9 (11)
1.861	1.058	0.985	1.102	1.110	0.920	1.061	2.3 (11)
1.858	1.054	0.983	1.104	1.110	0.920	1.081	2.5 (11)
1.879	1.054	0.984	1.108	1.114	0.920	1,063	3.1 (11)
1.854	1.041	0.970	1.104	1.110	0.914	1.063	4.1 (11)
1.863	1.055	0.985	1.120	1.131	0.928	1.080	4.7 (11)
1.871	1.060	0.987	1.142	1.151	0.940	1.096	6.3 (11)
1.931	1.068	0.991	1.156	1.170	0.949	1.100	7.4 (11)
1.867	1.055	0.984	1.153	1.160	0.940	1.100	8.4 (11)
1.859	1.055	0.981	1.225	1.260	0.968	1.147	7.2 (12)
1.855	1.051	0.982	1.409	1.510	1.040	1.266	2.6 (13)
1.835	1.050	0.981	1.581	1.701	1.110	1.330	4.3 (13)
1.839	1.054	0.980	1.640	1.825	1.130	1.415	4.8 (13)
1.861	1.058	0.986	1.772	2.007	1.195	1.516	6.3 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100° F

TABLE 3-48 RUN 3, FORWARD VOLTAGE CHARACTERISTICS (100° F), 1N3878

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3	4 *	
3.797	1.166	1.103	1.236	1.231	1.018	1.184	(1)
3.787	1.154	1.093	1.229	1.222	1.010	1.176	(2)
3.775	1.151	1.091	1.230	1.231	1.009	1.175	1.4 (10)
3.772	1.150	1.095	1.240	1.235	1.018	1.185	5.7 (10)
3.773	1.155	1.090	1.244	1.231	1.011	1.187	1.1 (11)
3.744	1.169	1.106	1.267	1.262	1.033	1.200	1.8 (11)
3.770	1.152	1.094	1.253	1.248	1.016	1.190	2.3 (11)
3.767	1.151	1.090	1.262	1.255	1.022	1.195	2.8 (11)
3.768	1.140	1.084	1.256	1.251	1.014	1.191	4.1 (11)
3.775	1.154	1.095	1.296	1.290	1.040	1.220	5.9 (11)
3.753	1.155	1.090	1.311	1.314	1.041	1.230	7.7 (11)
3.763	1.150	1.090	1.320	1.320	1.045	1.234	8.4 (11)
3.754	1.167	1.105	1.349	1.353	1.065	1.259	9.2 (11)
3.759	1.154	1.092	1.371	1.381	1.062	1.266	2.4 (12)
3.755	1.151	1.090	1.400	1.480	1.100	1.321	1.1 (13)
3.755	1.151	1.090	1.570	1.645	1.125	1.365	1.9 (13)
3.770	1.164	1.104	1.700	1.817	1.207	1.487	2.7 (13)
3.765	1.150	1.091	1.831	1.995	1.251	1.570	3.8 (13)
3.767	1.155	1.096	1.985	2.001	1.316	1.661	4.9 (13)
3.765	1.168	1.106	2.177	2.462	1.403	1.803	6.0 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100° F

TABLE 3-49 RUN 3, FORWARD VOLTAGE CHARACTERISTICS (160° F), 1N3878

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	11	12	7*	8	9	10	
3.960	1.247	1.332	1.296	1.502	1.346	1.451	(1)
3.960	1.045	1.139	1.254	1.200	1.050	1.141	4.7 (10)
3.958	1.042	1.130	1.260	1.204	1.050	1.144	1.1 (11)
4.242	1.006	1.144	1.282	1.200	1.060	1.100	2.1 (11)
4.078	1.054	1.147	1.313	1.240	1.074	1.185	3.9 (11)
4.099	1.044	1.140	1.354	1.254	1.084	1.205	6.3 (11)
3.845	1.039	1.130	1.394	1.201	1.090	1.210	1.1 (12)

(1) Pre Test at Ambient Temperature

TABLE 3-50 RUN 4, REVERSE LEAKAGE CHARACTERISTICS (100° F), 1N3878

Reverse Voltage (VDC)	Reverse Leakage (μA)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3	4	
284.5	3.502	3.962	6.502	26.411	6.161	5.412	(1)
284.8	5.401	7.249	10.007	34.502	8.699	9.132	(2)
285.1	5.602	7.400	11.005	30.005	9.229	9.904	1.6 (10)
285.0	5.451	7.242	12.042	37.719	9.009	9.009	7.4 (10)
284.9	5.431	7.231	12.222	39.742	9.009	9.812	1.1 (11)
285.1	5.482	7.211	12.529	45.311	9.311	10.231	2.0 (11)
284.9	5.701	7.703	13.007	46.782	9.511	10.701	2.3 (11)
284.9	6.001	8.101	14.106	47.499	10.232	11.401	2.6 (11)
285.1	6.402	8.842	15.005	52.713	10.612	11.892	3.0 (11)
285.1	7.547	10.455	18.099	59.301	12.079	15.004	3.4 (11)
285.1	8.007	11.101	19.672	62.001	13.052	15.507	3.6 (11)
284.9	9.232	12.807	22.002	65.739	14.401	17.298	4.1 (11)
284.9	9.722	13.542	23.059	67.099	14.692	18.002	4.3 (11)
284.9	10.392	14.412	24.007	68.402	15.401	19.103	4.6 (11)
284.9	4.699	8.142	13.299	52.702	9.843	11.012	4.8 (11)
284.8	5.642	7.632	15.002	58.049	9.902	11.002	5.7 (11)
284.9	5.149	7.052	15.001	60.399	9.099	10.602	7.1 (11)
284.9	6.102	8.182	17.404	60.699	10.391	11.449	8.4 (11)
284.4	5.471	7.322	30.399	92.799	15.029	18.399	6.3 (13)

(1) Pre Test at Ambient
(2) Pre Test at 100° F

TABLE 3-51 RUN 5, REVERSE LEAKAGE CHARACTERISTICS (100° F), 1N3878

Reverse Voltage (VDC)	Reverse Leakage (μA)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3	4	
327.9	3.701	4.212	6.769	30.099	7.442	5.608	(1)
328.0	5.702	7.562	11.001	39.182	10.099	9.602	(2)
328.4	5.609	7.589	11.482	40.002	9.822	9.521	9.2 (9)
328.2	5.601	7.591	12.519	43.501	10.007	10.271	7.6 (10)
328.1	5.642	7.636	13.104	46.804	10.442	10.332	1.2 (11)
328.2	5.842	7.757	14.042	50.099	10.782	10.962	2.2 (11)
327.8	6.101	8.229	15.052	58.889	14.782	12.099	3.8 (11)
328.1	9.605	13.451	23.022	73.599	15.781	18.312	4.1 (11)
328.1	10.141	14.342	24.669	76.799	16.292	18.901	4.3 (11)
328.1	10.842	15.332	26.039	79.005	17.422	16.675	4.6 (11)
328.1	6.202	8.481	15.213	62.007	11.325	11.069	4.9 (11)
328.1	5.402	7.542	15.099	67.262	10.511	10.902	6.8 (11)
328.1	5.881	7.952	17.004	74.012	11.001	11.701	7.7 (11)
328.1	6.352	8.562	18.629	80.302	11.299	12.001	8.4 (11)
328.1	6.402	8.675	19.008	81.099	12.252	10.079	1.0 (12)
320.0	6.212	8.458	22.412	88.003	12.392	13.362	8.4 (12)
327.9	3.590	5.590	30.040	104.01	15.010	18.610	6.3 (13)

(1) Pre Test at Ambient
(2) Pre Test at 100° F

TABLE 3-52 RUN 6, REVERSE LEAKAGE CHARACTERISTICS (100° F) 1N3878

Reverse Voltage (VDC)	Reverse Leakage (μA)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1*	2	3	4	
371.6	4.012	4.498	7.302	34.579	9.302	5.921	(1)
371.6	6.012	8.061	11.842	44.089	12.502	10.152	(2)
371.8	6.004	8.172	12.592	43.262	12.004	10.308	3.1 (9)
371.8	5.842	7.862	12.604	47.301	11.404	9.769	6.4 (10)
371.7	5.811	7.871	12.801	50.009	11.212	10.102	1.1 (11)
371.8	6.112	8.132	13.099	60.001	12.401	11.512	2.0 (11)
371.7	6.301	8.501	14.499	61.001	12.001	11.829	2.4 (11)
371.8	7.042	8.873	17.004	69.039	13.001	13.739	3.1 (11)
371.9	8.802	12.579	22.069	80.019	16.499	17.582	3.6 (11)
371.6	10.501	15.241	26.232	80.899	18.001	19.901	4.4 (11)
371.6	11.112	16.112	27.007	87.079	19.852	21.042	4.7 (11)
371.6			12.990	73.990	10.240	10.072	5.7 (11)
371.7	5.712	7.891	13.652	73.999	9.408	8.722	6.6 (11)
371.6	5.702	7.789	15.729	80.079	11.352	10.999	7.4 (11)
371.6	6.632	9.296	20.042	80.039	13.099	13.332	8.4 (11)
371.5	6.452	8.914	22.702	90.001	13.699	13.399	4.5 (12)
371.5	6.402	8.952	23.329	90.002	14.032	14.019	5.8 (12)
371.6	6.442	8.932	32.329	110.29	17.701	14.999	2.1 (13)
371.6	6.312	8.952	41.201	130.39	21.899	24.101	4.0 (13)
371.6	6.452	8.869	56.872	136.99	25.699	29.005	5.6 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100° F

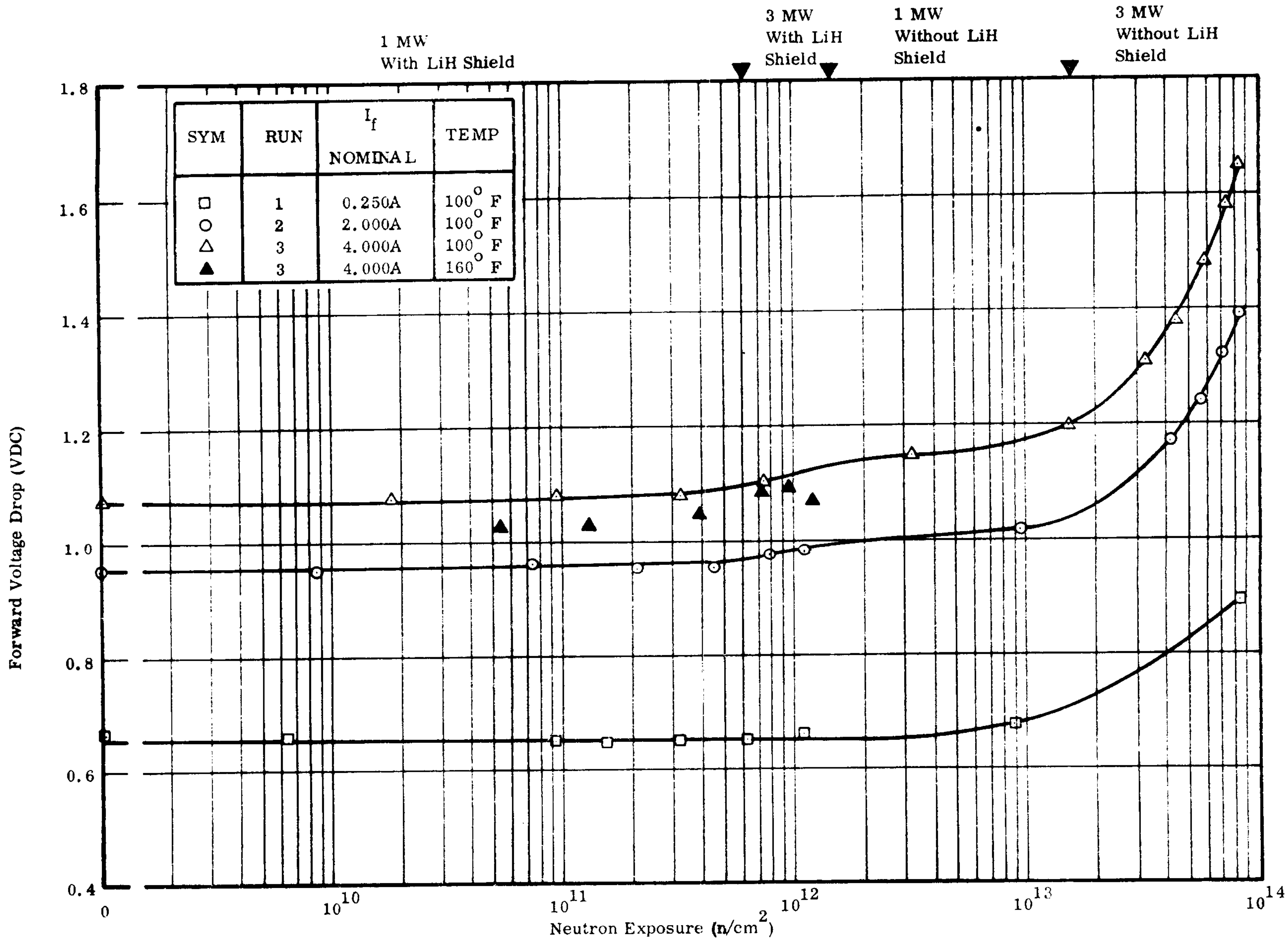


FIGURE 3-20 FORWARD VOLTAGE DROP VERSUS NEUTRON EXPOSURE, 1N3888 (TYPICAL)

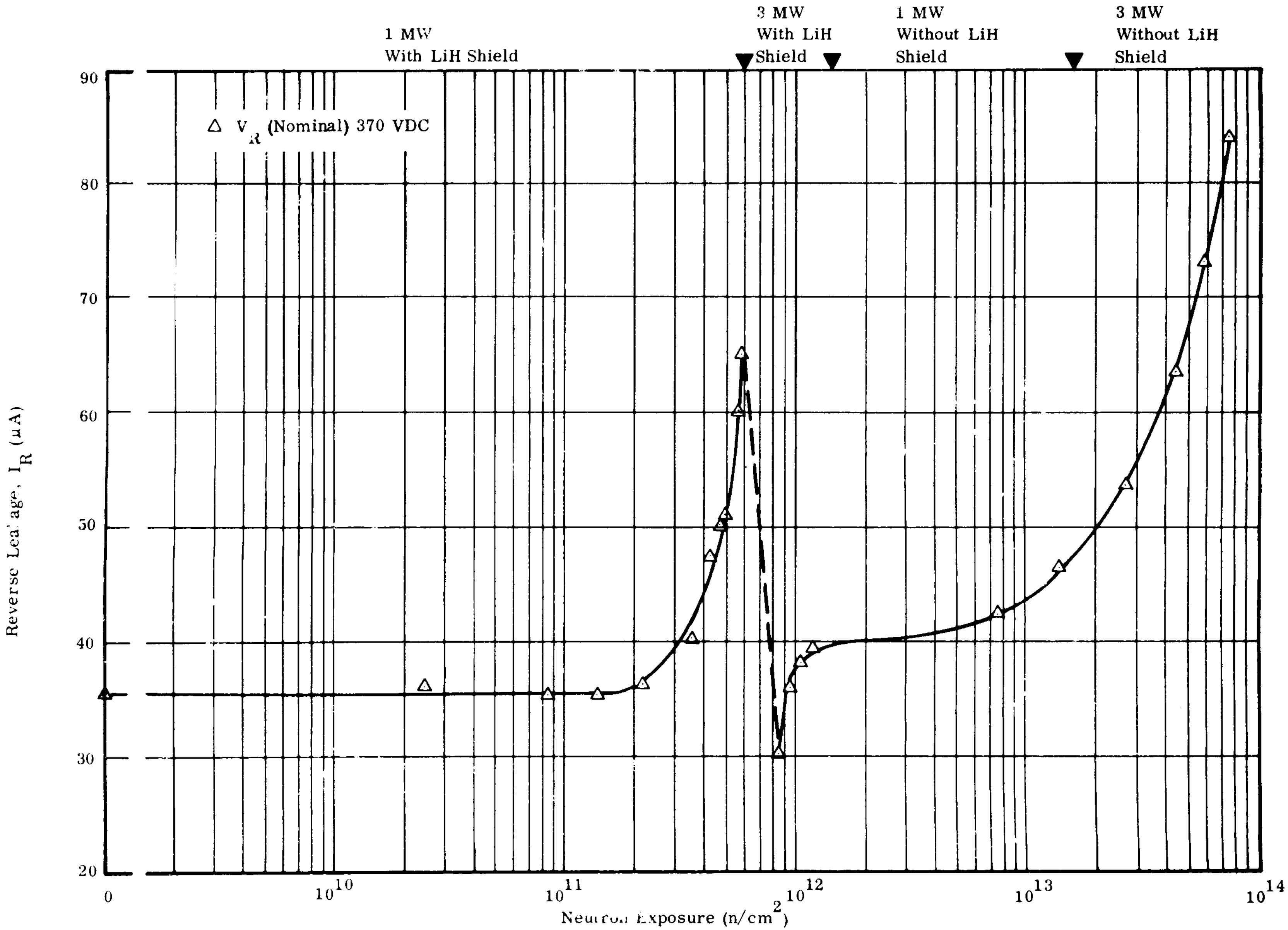


FIGURE 3-21 REVERSE LEAKAGE VERSUS NEUTRON EXPOSURE, 1N3888 (TYPICAL), 100° F

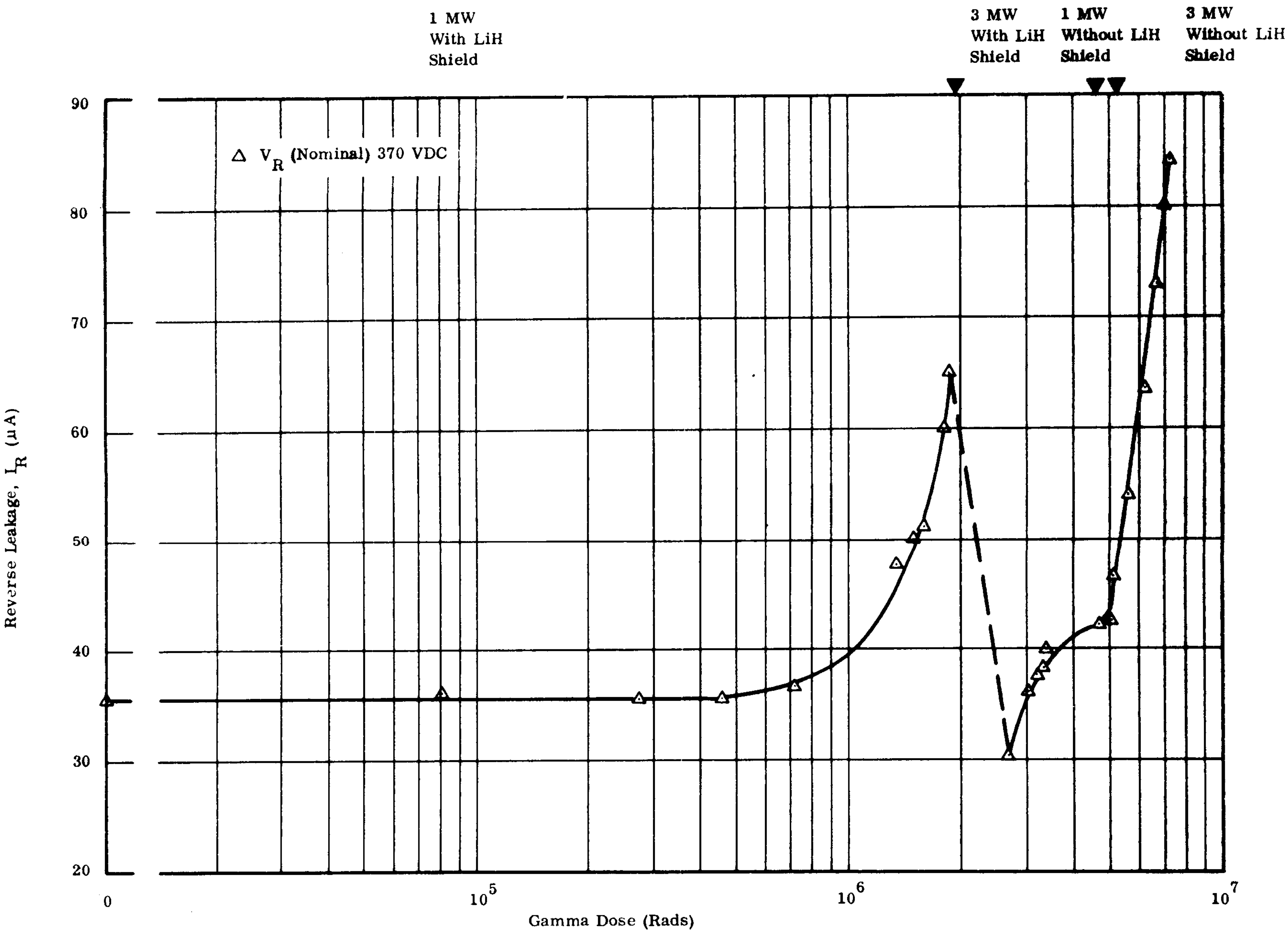


FIGURE 3-22 REVERSE LEAKAGE VERSUS GAMMA DOSE, 1N3888 (TYPICAL), 100° F

TABLE 3-53 RUN 1, FORWARD VOLTAGE CHARACTERISTICS, 100° F, 1N3888

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm²)
	Control Diodes		Irradiated Diodes				
	5	6	1 *	2	3	4	
0.203	0.727	0.703	0.670	0.643	0.661	0.635	(1)
0.207	0.704	0.674	0.665	0.636	0.650	0.631	(2)
0.198	0.701	0.669	0.660	0.630	0.644	0.631	6.4 (9)
0.186	0.695	0.664	0.654	0.615	0.608	0.620	9.0 (10)
0.183	0.695	0.664	0.661	0.634	0.646	0.632	1.3 (11)
0.186	0.695	0.663	0.653	0.625	0.631	0.621	1.5 (11)
0.185	0.696	0.661	0.660	0.634	0.649	0.635	1.9 (11)
0.182	0.693	0.660	0.650	0.621	0.634	0.629	2.3 (11)
0.188	0.691	0.666	0.665	0.635	0.650	0.634	2.7 (11)
0.181	0.690	0.660	0.651	0.620	0.638	0.620	3.1 (11)
0.184	0.693	0.661	0.660	0.630	0.643	0.631	3.6 (11)
0.191	0.681	0.650	0.648	0.614	0.631	0.615	4.3 (11)
0.194	0.684	0.641	0.654	0.620	0.630	0.622	4.8 (11)
0.186	0.680	0.649	0.650	0.624	0.634	0.619	6.1 (11)
0.184	0.689	0.660	0.655	0.626	0.640	0.623	7.1 (11)
0.190	0.697	0.665	0.668	0.634	0.647	0.631	8.6 (11)
0.186	0.689	0.656	0.659	0.628	0.643	0.636	1.1 (12)
0.187	0.689	0.657	0.661	0.630	0.644	0.625	1.2 (12)
0.183	0.686	0.651	0.675	0.640	0.655	0.639	8.1 (12)
0.206	0.705	0.674	0.893	0.834	0.866	0.822	8.2 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100° F

TABLE 3-54 RUN 2, FORWARD VOLTAGE CHARACTERISTICS (100°F) 1N3888

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3	4	
1.883	0.947	0.963	0.970	0.903	0.920	0.897	(1)
1.871	0.930	0.930	0.950	0.907	0.900	0.880	(2)
1.865	0.930	0.933	0.950	0.910	0.900	0.890	8.6 (9)
1.861	0.934	0.941	0.959	0.917	0.915	0.889	7.3 (10)
1.862	0.900	0.930	0.951	0.900	0.901	0.880	1.1 (11)
1.862	0.930	0.935	0.953	0.910	0.905	0.881	1.4 (11)
1.861	0.930	0.936	0.954	0.910	0.907	0.881	2.1 (11)
1.859	0.930	0.931	0.960	0.912	0.911	0.889	2.7 (11)
1.860	0.921	0.930	0.957	0.911	0.910	0.880	3.6 (11)
1.865	0.920	0.925	0.950	0.904	0.907	0.882	4.5 (11)
1.861	0.916	0.914	0.943	0.900	0.904	0.874	5.5 (11)
1.867	0.928	0.931	0.965	0.920	0.919	0.890	6.1 (11)
1.856	0.930	0.935	0.975	0.929	0.927	0.900	7.7 (11)
1.881	0.932	0.940	0.973	0.930	0.930	0.900	8.6 (11)
1.871	0.928	0.934	0.981	0.936	0.931	0.904	1.1 (12)
1.864	0.900	0.930	1.020	0.970	0.970	0.937	9.4 (12)
1.842	0.929	0.930	1.174	1.100	1.120	1.060	4.2 (13)
1.839	0.927	0.930	1.245	1.170	1.160	1.100	5.6 (13)
1.839	0.923	0.932	1.321	1.236	1.260	1.180	6.9 (13)
1.865	0.933	0.930	1.391	1.301	1.330	1.237	8.2 (13)

(1) Pre Test at Ambient
(2) Pre Test at 100°F

TABLE 3-55 RUN 3, FORWARD VOLTAGE CHARACTERISTICS (100°F) 1N3888

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1 *	2	3	4	
3.778	1.031	1.000	1.090	1.040	1.000	1.004	(1)
3.781	1.011	1.041	1.077	1.023	1.000	.994	(2)
3.759	1.015	1.045	1.075	1.020	1.014	.990	1.8 (10)
3.763	1.016	1.045	1.080	1.024	1.019	.993	9.4 (10)
3.763	1.011	1.044	1.084	1.037	1.020	.994	1.7 (11)
3.756	1.014	1.044	1.084	1.030	1.026	.998	2.5 (11)
3.760	1.014	1.040	1.080	1.030	1.029	1.000	3.2 (11)
3.756	1.000	1.030	1.086	1.024	1.030	.998	4.8 (11)
3.757	1.010	1.044	1.106	1.040	1.050	1.015	7.3 (11)
3.766	1.023	1.052	1.116	1.050	1.054	1.020	8.6 (11)
3.743	1.016	1.041	1.120	1.060	1.056	1.025	1.0 (12)
3.744	1.015	1.041	1.125	1.065	1.064	1.027	1.2 (12)
3.743	1.016	1.041	1.150	1.086	1.090	1.055	3.2 (12)
3.752	1.015	1.041	1.179	1.110	1.115	1.070	9.9 (12)
3.739	1.011	1.041	1.205	1.137	1.140	1.087	1.5 (13)
3.750	1.016	1.042	1.316	1.230	1.205	1.185	3.2 (13)
3.760	1.016	1.041	1.389	1.291	1.315	1.247	4.3 (13)
3.753	1.011	1.043	1.483	1.375	1.406	1.323	5.7 (13)
3.753	1.014	1.043	1.583	1.466	1.501	1.397	7.1 (13)
3.765	1.007	1.046	1.651	1.535	1.571	1.453	8.2 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100°F

TABLE 3-56 RUN 3, FORWARD VOLTAGE CHARACTERISTICS (160°F) 1N3888

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3	4 *	
3.984	0.963	0.887	1.130	0.911	0.984	1.110	(1)
3.974	0.900	0.839	1.007	0.850	0.900	1.030	5.5 (10)
3.942	0.900	0.837	1.000	0.864	0.925	1.033	1.3 (11)
4.049	0.903	0.835	1.090	0.805	0.940	1.050	3.9 (11)
3.944	0.904	0.841	1.124	0.903	0.964	1.085	7.3 (11)
3.940	0.915	0.850	1.141	0.911	0.971	1.097	9.5 (11)
3.820	0.894	0.831	1.101	0.890	0.949	1.074	1.2 (12)

(1) Pre Test at Ambient Temperature

TABLE 3-57 RUN 4, REVERSE LEAKAGE CHARACTERISTICS (100°F) 1N3888

Reverse Voltage (VDC)	Reverse Leakage (μA)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3	4	
284.6	9.802	10.119	10.862	11.499	32.552	12.399	(1)
284.9	17.501	18.502	29.501	21.769	31.792	23.409	(2)
285.2	17.332	18.202	31.002	21.099	30.019	23.221	1.2 (10)
285.0	16.602	17.442	30.309	23.032	32.049	23.049	7.7 (10)
285.0	17.412	18.262	31.202	24.772	-	25.602	9.6 (10)
284.9	17.243	18.072	31.429	25.080	30.199	25.079	1.9 (11)
285.0	17.329	18.222	31.389	25.999	33.002	26.231	2.7 (11)
285.0	19.201	20.212	34.101	30.091	43.059	29.201	3.4 (11)
285.1	24.801	26.009	45.405	40.059	58.999	39.699	4.4 (11)
284.8	30.069	32.691	54.009	51.683	67.102	40.002	5.3 (11)
284.8	35.001	37.142	60.039	59.002	83.039	54.609	6.0 (11)
284.8	19.099	20.032	30.499	42.611	54.659	29.232	6.4 (11)
284.8	18.007	19.102	32.692	52.209	-	28.707	6.9 (11)
284.8	16.001	17.232	30.079	54.008	40.004	26.042	8.8 (11)
284.9	17.622	18.479	31.399	61.999	60.007	28.629	9.9 (11)
284.8	19.142	20.049	34.219	-	60.729	30.302	1.1 (12)
284.4	17.432	18.232	63.029	-	69.006	60.649	8.2 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100°F

TABLE 3-58 RUN 5, REVERSE LEAKAGE CHARACTERISTICS (100°F) 1N3888

Reverse Voltage (VDC)	Reverse Leakage (μA)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3	4	
328.0	10.942	10.801	19.001	11.802	47.899	13.202	(1)
328.0	18.629	19.031	32.001	21.069	54.399	23.099	(2)
328.1	19.105	19.299	31.001	23.042	34.199	24.382	1.7 (9)
328.2	18.502	18.712	32.701	25.108	30.499	25.101	8.2 (10)
328.1	19.005	19.112	33.002	25.099	33.019	26.999	1.7 (11)
328.2	19.001	19.519	34.069	28.141	38.069	27.751	2.9 (11)
328.2	19.531	19.612	34.605	30.627	40.049	29.172	3.1 (11)
328.2	21.892	22.101	38.512	30.999	70.899	31.172	3.8 (11)
328.4	27.001	27.331	46.499	44.102	72.999	41.004	4.4 (11)
328.1	34.102	34.839	59.019	55.499	78.999	50.312	5.5 (11)
328.1	38.001	38.701	64.999	63.069	87.003	56.099	6.0 (11)
328.1	20.299	20.629	35.212	48.007	74.949	30.002	6.4 (11)
328.1	17.802	18.011	32.405	30.999	64.499	27.002	8.9 (11)
328.1	19.412	19.672	34.399	91.001	89.699	-	9.9 (11)
328.1	20.079	21.001	35.799	125.99	90.039	31.302	1.1 (12)
328.1	21.101	21.342	37.219	150.00	100.29	30.059	1.3 (12)
328.0	20.699	20.001	40.699	202.99	96.602	35.001	1.1 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100°F

TABLE 3-59 RUN 6, REVERSE LEAKAGE CHARACTERISTICS (100°F) 1N3888

Reverse Voltage (VDC)	Reverse Leakage (μA)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1 *	2	3	4	
371.6	12.811	11.631	21.032	12.102	63.659	13.602	(1)
371.6	21.039	20.111	35.429	22.407	73.001	24.269	(2)
371.6	21.682	20.332	36.082	27.004	23.999	27.279	2.5 (10)
371.7	21.099	19.802	35.389	25.599	35.059	26.601	8.6 (10)
371.6	21.142	19.801	35.322	27.721	36.599	20.049	1.4 (11)
371.6	21.701	20.232	36.379	29.239	40.199	28.229	2.2 (11)
371.7	21.049	20.119	36.099	30.005	45.479	27.799	2.8 (11)
371.6	24.229	22.692	40.207	35.399	55.199	32.479	3.6 (11)
371.8	22.999	26.382	47.599	43.202	72.299	39.004	4.3 (11)
371.8	21.802	20.001	50.049	50.002	80.999	45.079	4.7 (11)
371.4	29.602	28.099	51.004	58.549	-	51.601	5.0 (11)
371.5	39.009	35.999	60.069	62.569	111.99	54.412	5.7 (11)
371.6	38.599	37.522	65.299	66.352	-	58.005	5.8 (11)
371.6	19.408	18.019	30.099	20.802	95.02	27.292	8.6 (11)
371.6	20.312	19.141	36.007	22.999	-	28.379	9.6 (11)
371.6	22.141	20.539	37.499	114.59	110.01	31.002	1.0 (12)
371.6	22.011	20.599	38.104	110.59	115.59	-	1.02 (12)
371.6	22.699	21.211	38.019	120.00	-	32.001	1.05 (12)
371.6	20.001	21.069	39.999	130.09	119.99	32.072	1.07 (12)
371.6	23.329	22.001	39.339	155.00	120.29	30.001	1.2 (12)
371.5	23.002	22.012	40.039	235.49	144.99	33.901	3.9 (12)
371.5	23.292	21.912	42.559	240.04	133.19	34.901	7.5 (12)
371.5	23.222	21.902	46.499	253.79	180.06	37.003	1.4 (13)
371.5	20.399	21.399	53.799	342.99	102.04	49.434	2.7 (13)
371.5	22.008	21.101	63.499	300.03	100.04	59.019	4.4 (13)
371.5	22.599	21.302	72.999	302.99	105.29	72.212	5.8 (13)
371.5	22.619	21.001	80.039	280.89	102.99	76.429	6.6 (13)
371.5	22.792	21.404	83.89	250.49	100.49	80.00	7.5 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100°F

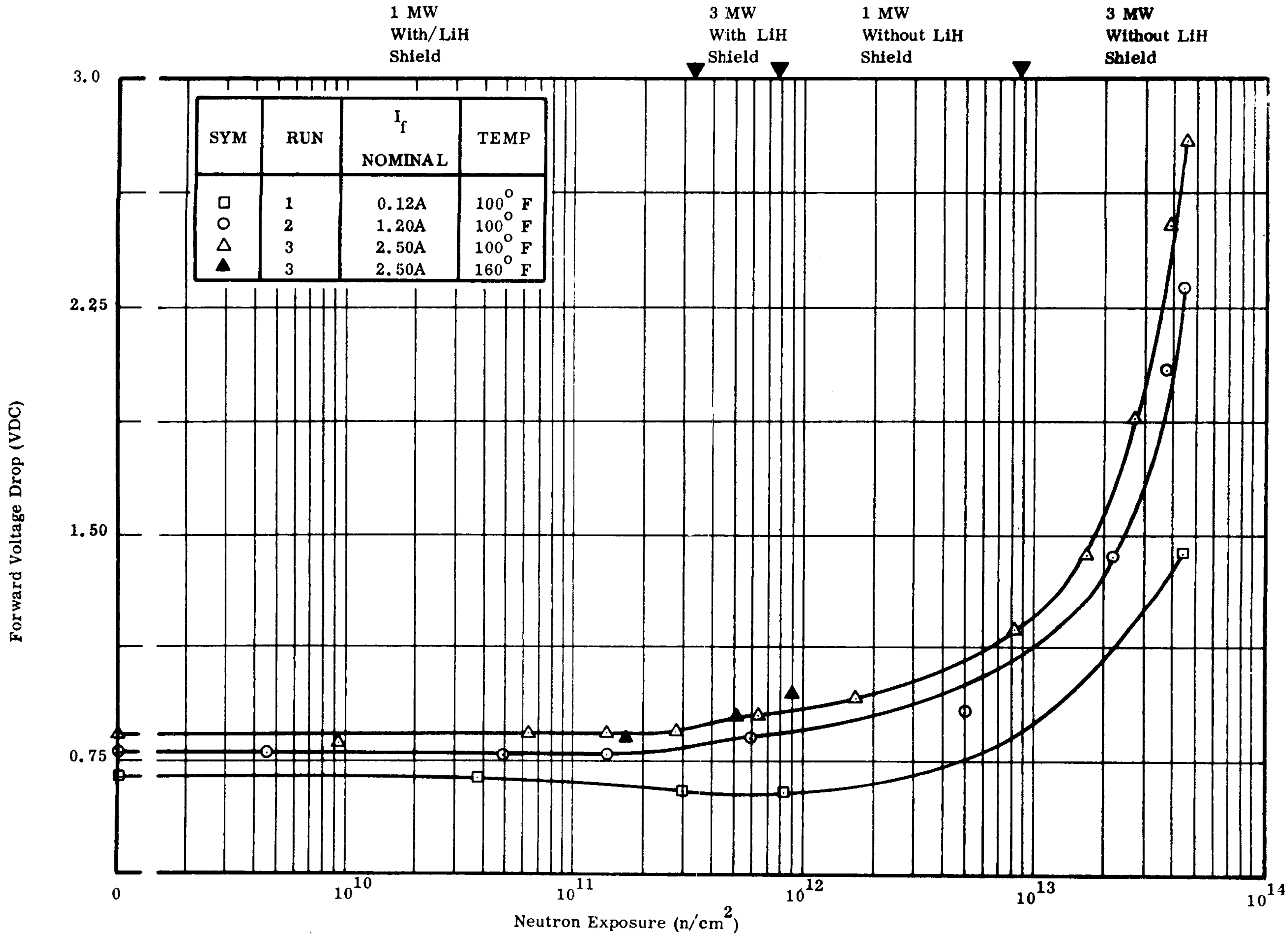


FIGURE 3-23 FORWARD VOLTAGE DROP VERSUS NEUTRON EXPOSURE, GE-91 (TYPICAL)

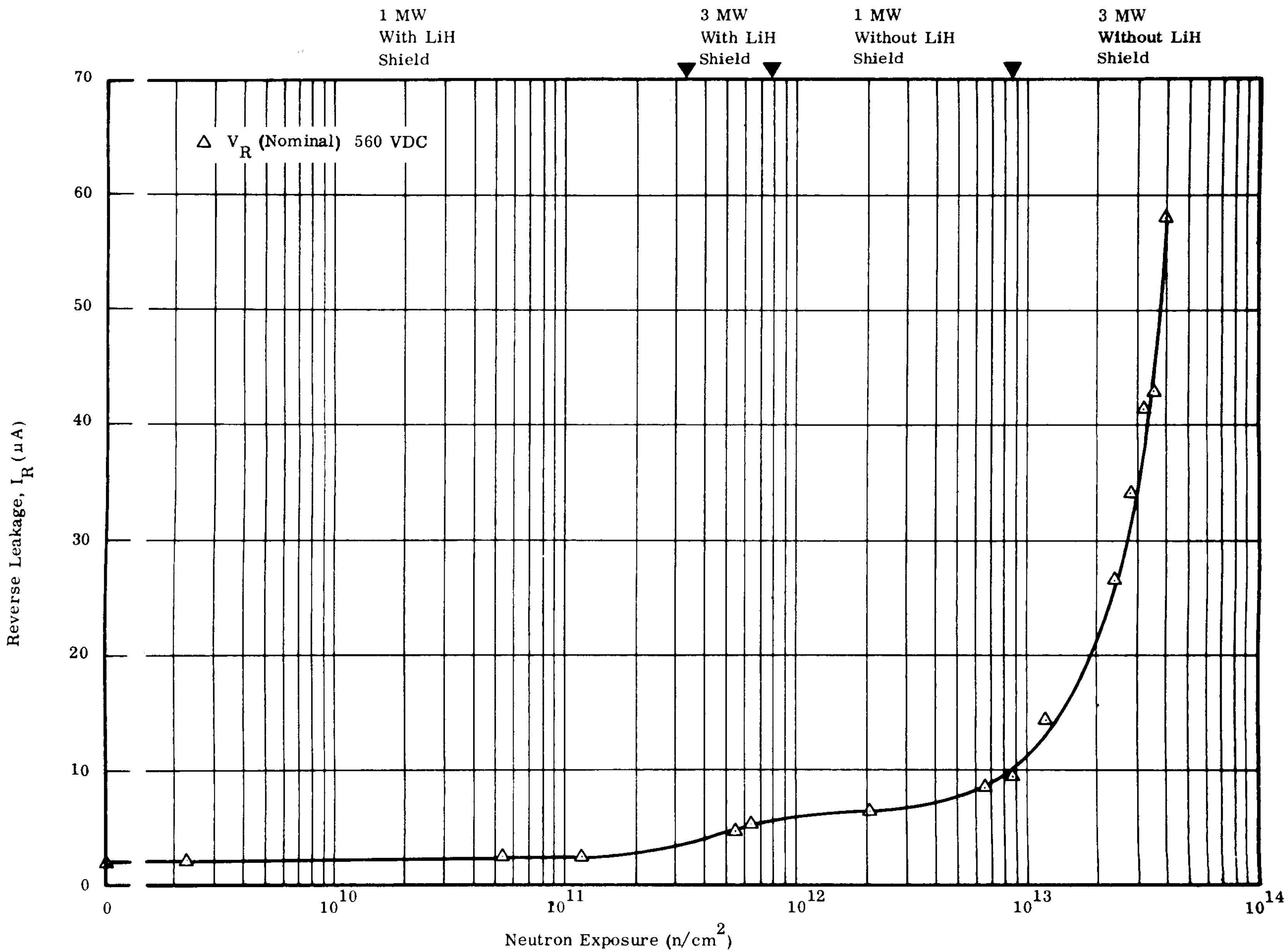


FIGURE 3-24 REVERSE LEAKAGE VERSUS NEUTRON EXPOSURE, GE-91 (TYPICAL), 100° F

TABLE 3-60 RUN 1, FORWARD VOLTAGE CHARACTERISTICS (100°F) GE-91

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3	4 *	
0.248	0.725	0.729	0.707	0.703	0.693	0.702	(1)
0.220	0.705	0.711	0.694	0.692	0.680	0.691	(2)
0.144	0.680	0.690	0.663	0.660	0.644	0.657	3.4 (9)
0.139	0.705	0.710	0.687	0.686	0.681	0.689	3.8 (10)
0.141	0.685	0.690	0.639	0.631	0.633	0.645	5.9 (10)
0.145	0.686	0.693	0.640	0.639	0.636	0.644	7.8 (10)
0.139	0.685	0.695	0.631	0.632	0.630	0.635	1.1 (11)
0.136	0.685	0.693	0.630	0.630	0.628	0.635	1.3 (11)
0.156	0.691	0.690	0.650	0.653	0.654	0.660	1.5 (11)
0.165	0.690	0.691	0.643	0.644	0.644	0.650	1.7 (11)
0.209	0.700	0.704	0.656	0.659	0.659	0.664	2.1 (11)
0.198	0.693	0.691	0.650	0.653	0.654	0.655	2.3 (11)
0.201	0.686	0.693	0.644	0.649	0.642	0.650	3.0 (11)
0.232	0.692	0.696	0.652	0.663	0.659	0.661	3.2 (11)
0.148	0.680	0.691	0.650	0.656	0.650	0.656	4.1 (11)
0.183	0.700	0.702	0.681	0.687	0.679	0.686	4.6 (11)
0.191	0.699	0.704	0.665	0.674	0.664	0.669	5.2 (11)
0.193	0.679	0.702	0.672	0.679	0.665	0.671	5.8 (11)
0.208	0.700	0.705	0.690	0.700	0.680	0.685	7.2 (11)
0.176	0.697	0.702	1.493	1.599	1.281	1.441	4.4 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100°F

TABLE 3-61 RUN 2, FORWARD VOLTAGE CHARACTERISTICS (100°F) GE-91

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3	4*	
1.205	0.801	0.798	0.675	0.788	0.785	0.790	(1)
1.197	0.790	0.787	0.673	0.782	0.780	0.780	(2)
1.090	0.785	0.780	-	0.774	0.771	0.777	4.6 (9)
1.127	0.793	0.792	-	0.789	0.789	0.791	3.0 (10)
1.143	0.788	0.784	-	0.775	0.775	0.777	4.9 (10)
1.113	0.787	0.784	-	0.778	0.779	0.780	7.2 (10)
1.115	0.787	0.784	-	0.771	0.780	0.781	1.1 (11)
1.142	0.788	0.785	-	0.780	0.780	0.779	1.4 (11)
1.130	0.796	0.792	-	0.795	0.794	0.795	1.6 (11)
1.110	0.786	0.783	-	0.784	0.783	0.784	2.0 (11)
1.162	0.781	0.778	-	0.790	0.783	0.784	2.9 (11)
1.136	0.771	0.771	-	0.785	0.778	0.775	3.2 (11)
1.153	0.786	0.780	-	0.810	0.796	0.799	3.9 (11)
1.132	0.791	0.793	-	0.840	0.822	0.821	4.6 (11)
1.168	0.788	0.784	-	0.820	0.820	0.825	5.8 (11)
1.120	0.784	0.781	-	0.975	0.899	0.913	5.0 (12)
1.134	0.790	0.786	-	1.656	1.311	1.430	2.2 (13)
1.096	0.784	0.781	-	2.010	1.540	1.730	3.0 (13)
1.082	0.781	0.730	-	2.396	1.791	2.040	3.7 (13)
1.178	0.790	0.787	-	2.723	2.022	2.319	4.4 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100°F

TABLE 3-62 RUN 3, FORWARD VOLTAGE CHARACTERISTICS (100°F) GE-91

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3	4*	
2.539	0.810	0.805	-	-	0.840	0.836	(1)
2.581	0.841	0.831	-	-	0.834	0.833	(2)
2.494	0.838	0.822	-	-	0.825	0.820	9.6 (9)
2.552	0.840	0.830	-	-	0.828	0.835	6.3 (10)
2.484	0.839	0.820	-	-	0.830	0.833	8.8 (10)
2.586	0.841	0.830	-	-	0.822	0.840	1.4 (11)
2.580	0.840	0.830	-	-	0.829	0.845	1.7 (11)
2.523	0.836	0.825	-	-	0.841	0.840	2.2 (11)
2.489	0.826	0.818	-	-	0.831	0.846	2.8 (11)
2.481	0.825	0.815	-	-	0.842	0.840	3.2 (11)
2.569	0.840	0.830	-	-	0.868	0.880	4.4 (11)
2.518	0.838	0.829	-	-	0.891	0.896	5.5 (11)
2.476	0.836	0.826	-	-	0.890	0.900	6.3 (11)
2.467	0.836	0.825	-	-	0.905	0.960	1.7 (12)
2.478	0.836	0.826	-	-	1.029	1.078	7.3 (12)
2.521	0.838	0.827	-	-	1.060	1.187	8.2 (12)
2.470	0.833	0.826	-	-	1.300	1.435	1.7 (13)
2.529	0.838	0.828	-	-	1.658	1.895	2.7 (13)
2.471	0.836	0.826	-	-	2.007	2.522	3.8 (13)
2.545	0.840	0.830	-	-	2.304	2.805	4.4 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100°F

TABLE 3-63 RUN 3, FORWARD VOLTAGE CHARACTERISTICS (160°F) GE-91

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	11	12	7	8	9	10 *	
2.571	0.778	-	0.719	0.889	0.810	-	1.1 (9)
2.607	0.790	0.793	-	1.080	0.826	0.825	1.7 (11)
2.614	0.811	0.808	-	1.533	1.228	1.222	4.0 (11)
2.605	0.797	0.791	-	1.159	0.910	0.898	5.2 (11)
2.629	0.793	0.794	-	1.139	0.990	0.970	8.8 (11)

TABLE 3-64 RUN 4, REVERSE LEAKAGE CHARACTERISTICS (100°F) GE-91

Reverse Voltage (VDC)	Reverse Leakage (μA)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3	4	
243.5	0.081	0.405	0.601	0.511	0.672	0.922	(1)
243.8	1.252	0.572	0.704	1.252	1.312	1.259	(2)
244.0	1.304	0.622	1.012	1.271	1.272	1.441	1.1 (10)
243.9	1.172	0.542	1.012	1.142	1.107	1.278	4.1 (10)
244.0	1.322	0.449	1.122	1.301	1.302	1.481	6.3 (10)
243.8	1.222	0.542	1.211	1.501	1.521	1.519	1.2 (11)
244.0	1.301	0.532	1.342	1.621	1.541	1.519	1.5 (11)
243.9	1.001	0.489	1.332	1.401	1.342	1.433	1.7 (11)
243.9	1.188	0.507	1.482	1.849	1.742	1.798	1.8 (11)
244.0	1.351	0.599	1.572	2.001	1.872	2.011	2.2 (11)
243.4	1.008	0.529	1.582	1.922	1.722	1.877	2.7 (11)
243.8	1.632	0.701	2.121	2.652	2.001	2.511	2.9 (11)
243.8	1.311	0.612	2.262	2.652	2.241	2.332	3.4 (11)
243.8	1.182	0.522	2.312	2.602	2.222	2.273	4.5 (11)
243.8	1.217	0.502	2.405	2.832	2.341	2.342	5.3 (11)
243.8	1.301	0.561	2.641	3.201	2.569	2.639	5.9 (11)
243.8	1.452	0.612	2.962	3.501	2.852	2.919	6.8 (11)
243.7	1.442	0.601	4.102	4.912	3.862	3.982	5.6 (12)
243.7	1.332	0.449	20.039	31.319	19.742	20.004	4.4 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100°F

TABLE 3-65 RUN 5, REVERSE LEAKAGE CHARACTERISTICS (100°F) GE-91

Reverse Voltage (VDC)	Reverse Leakage (μA)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3	4	
401.9	1.901	0.971	0.921	1.412	1.901	1.911	(1)
401.8	1.942	0.999	1.211	1.332	1.712	1.898	(2)
401.9	1.841	0.991	1.475	1.711	2.032	1.701	9.4 (8)
402.1	1.843	0.947	1.642	1.801	2.292	1.872	1.3 (10)
402.0	1.902	0.942	1.752	1.922	2.332	1.801	5.3 (10)
401.9	1.907	0.942	1.722	1.932	2.272	1.922	8.4 (10)
401.9	1.902	0.949	1.801	2.006	2.413	1.932	1.1 (11)
402.0	2.042	0.966	1.729	2.145	2.682	2.082	1.4 (11)
402.0	2.032	0.949	1.811	2.222	2.801	2.139	1.5 (11)
401.8	1.952	0.905	2.052	2.325	2.711	2.202	1.7 (11)
402.0	2.201	1.051	2.102	2.522	3.142	2.492	2.1 (11)
402.1	2.301	1.142	2.442	3.152	3.912	2.972	2.4 (11)
402.1	2.401	1.152	2.762	3.141	3.762	2.892	2.5 (11)
401.8	2.201	1.122	2.781	3.152	3.601	2.872	3.1 (11)
401.8	1.956	0.956	2.996	3.541	3.942	3.078	3.8 (11)
401.9	2.001	0.908	3.382	3.649	4.001	3.072	5.3 (11)
401.8	2.142	1.002	3.532	4.222	4.622	3.418	6.0 (11)
401.8	2.011	0.971	3.912	4.669	4.752	3.721	6.9 (11)
401.8	1.992	0.947	5.749	6.583	6.104	5.231	6.0 (12)
402.0	-	-	30.02	30.06	26.00	25.05	4.4 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100°F

TABLE 3-66 RUN 6, REVERSE LEAKAGE CHARACTERISTICS (100°F) GE-91

Reverse Voltage (VDC)	Reverse Leakage (μA)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2*	3	4	
567.3	2.372	1.135	1.222	1.079	4.602	2.192	(1)
567.3	2.812	1.419	1.562	1.952	5.101	2.702	(2)
567.4	2.802	1.372	2.042	2.328	5.007	2.454	2.2 (9)
567.4	2.831	1.375	2.082	2.522	5.749	2.542	5.4 (10)
567.3	2.741	1.301	2.512	2.671	6.501	2.672	1.2 (11)
567.4	3.242	1.549	2.862	3.252	10.002	3.042	1.9 (11)
567.3	3.802	1.852	4.392	4.618	14.058	4.242	2.9 (11)
567.3	4.142	1.732	4.741	5.179	13.002	4.642	3.3 (11)
567.4	2.902	1.381	5.129	4.701	17.099	4.022	5.5 (11)
567.3	3.101	1.441	5.912	5.279	12.999	4.422	6.3 (11)
567.3	3.042	1.422	7.202	6.502	12.001	5.228	2.1 (12)
567.3	2.905	1.432	9.102	8.481	12.239	6.832	6.6 (12)
567.4	3.273	1.502	10.079	9.602	12.372	7.731	8.6 (12)
567.3	3.372	1.462	14.601	14.472	16.008	11.702	1.2 (13)
567.3	2.912	1.201	16.212	15.722	18.099	13.052	2.0 (13)
567.3	-	1.389	26.292	26.409	24.108	20.319	2.4 (13)
567.3	3.182	1.412	32.899	34.102	-	25.539	2.8 (13)
567.3	3.212	1.372	41.029	41.362	36.007	29.802	3.2 (13)
567.3	3.242	1.442	48.079	42.990	39.999	30.099	3.5 (13)
567.3	3.242	1.398	50.049	58.439	44.999	40.005	3.9 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100°F

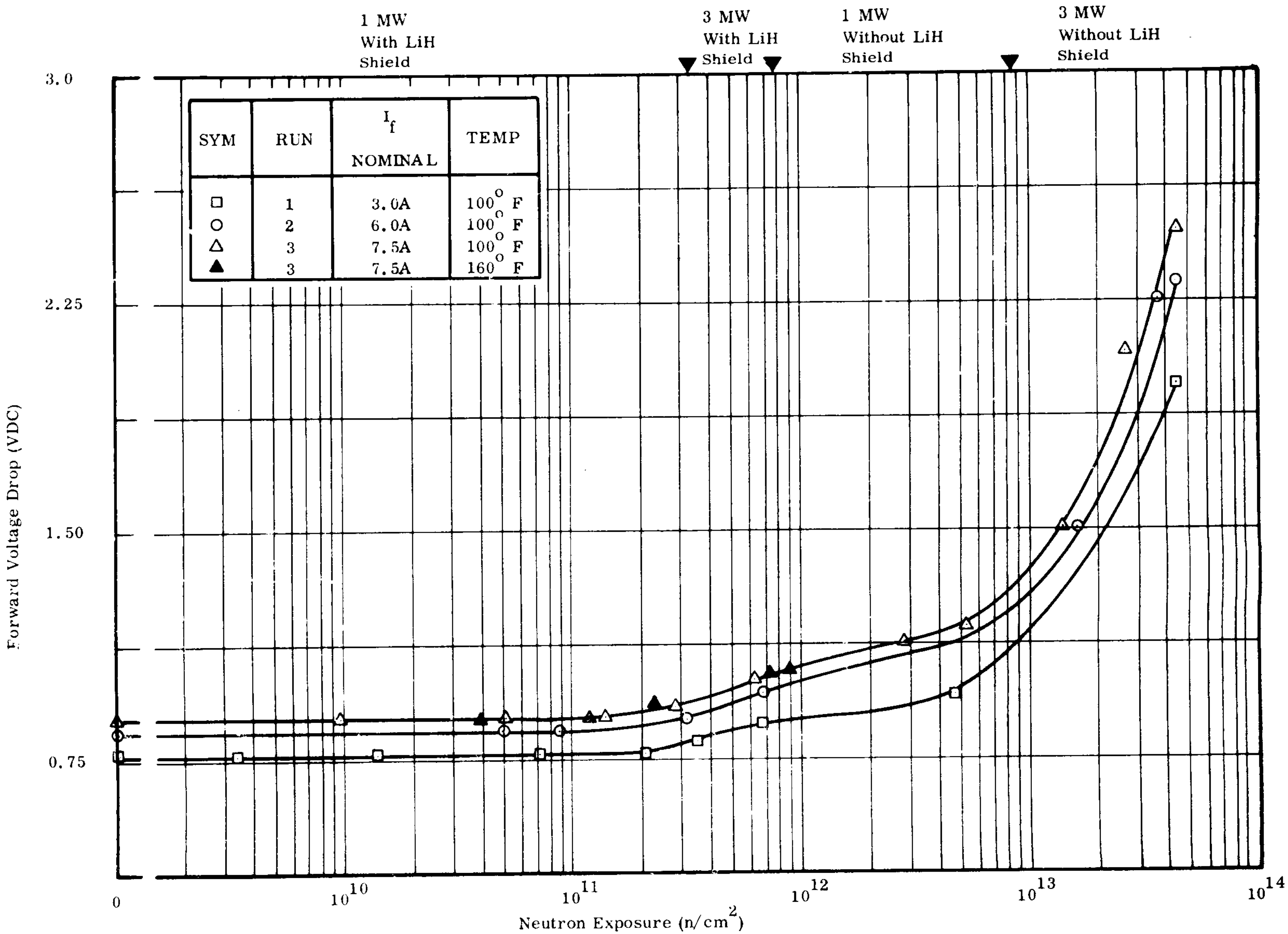


FIGURE 3-25 FORWARD VOLTAGE DROP VERSUS NEUTRON EXPOSURE, GE-92 (TYPICAL)

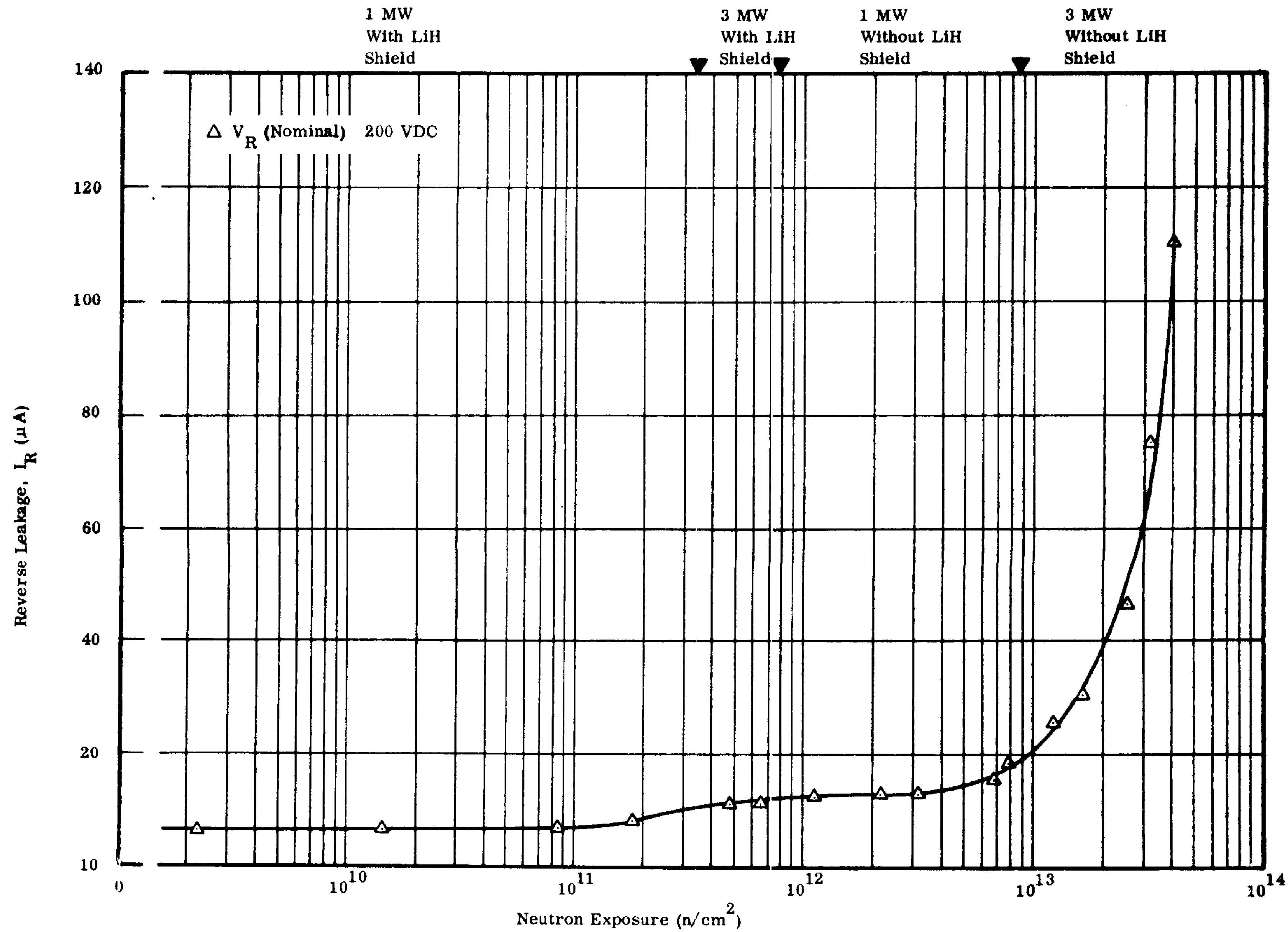


FIGURE 3-26 REVERSE LEAKAGE VERSUS NEUTRON EXPOSURE, GE-92 (TYPICAL), 100° F

TABLE 3-67 RUN 1, FORWARD VOLTAGE CHARACTERISTICS ($100^{\circ}F$) GE-92

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1*	2	3	4	
3.149	0.780	-	0.770	0.770	0.756	0.773	(1)
3.225	0.780	-	0.774	0.774	0.760	0.784	(2)
3.152	0.778	-	0.772	0.770	0.764	0.782	3.4 (9)
3.132	0.770	-	0.770	0.769	0.760	0.767	6.6 (9)
3.134	0.776	-	0.768	0.763	0.756	0.771	4.8 (10)
3.136	0.776	-	0.772	0.765	0.760	0.700	7.1 (10)
3.134	0.777	-	0.775	0.765	0.764	0.780	1.0 (11)
3.133	0.777	-	0.774	0.760	0.758	0.770	1.4 (11)
3.150	0.776	-	0.776	0.760	0.759	0.778	1.7 (11)
3.129	0.773	0.760	0.778	0.759	0.754	0.775	2.1 (11)
3.170	0.769	0.751	0.784	0.760	0.757	0.772	2.6 (11)
3.190	0.766	0.752	0.784	0.757	0.756	0.775	3.0 (11)
3.205	0.776	0.762	0.803	0.772	0.770	0.790	3.5 (11)
3.151	0.772	0.761	0.816	0.780	0.776	0.797	4.1 (11)
3.178	0.779	0.765	0.832	0.792	0.789	0.809	4.6 (11)
3.120	0.802	0.787	0.862	0.818	0.806	0.826	5.1 (11)
3.262	0.766	0.765	0.833	0.790	0.785	0.806	5.2 (11)
3.130	0.771	0.760	0.860	0.800	0.796	0.820	6.7 (11)
3.124	0.773	0.760	0.960	0.864	0.855	0.884	4.7 (12)
3.165	0.778	0.764	1.971	1.636	1.700	1.807	4.4 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at $100^{\circ}F$

TABLE 3-68 RUN 2, FORWARD VOLTAGE CHARACTERISTICS ($100^{o}F$) GE-92

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1*	2	3	4	
6.405	0.842	-	0.843	0.833	0.809	0.826	(1)
6.396	0.840	-	0.843	0.837	0.820	0.835	(2)
6.404	0.840	-	0.844	0.839	0.818	0.834	4.6 (9)
6.368	0.841	-	0.844	0.834	0.820	0.835	4.9 (10)
6.376	0.841	-	0.850	0.834	0.820	0.838	8.7 (10)
6.504	0.840	-	0.853	0.834	0.821	0.831	1.2 (11)
6.511	0.840	-	0.857	0.835	0.824	0.844	1.4 (11)
6.371	0.838	-	0.860	0.836	0.824	0.840	1.7 (11)
6.250	0.834	-	0.864	0.835	0.829	0.842	2.2 (11)
6.247	0.831	-	0.874	0.840	0.830	0.843	2.6 (11)
6.216	0.835	-	0.880	0.839	0.830	0.850	3.2 (11)
6.251	0.831	-	0.897	0.854	0.839	0.865	3.7 (11)
6.260	0.841	-	0.925	0.875	0.857	0.891	4.4 (11)
6.345	0.836	-	0.934	0.875	0.869	0.890	5.2 (11)
6.216	0.837	0.810	0.970	0.895	0.880	0.985	6.8 (11)
6.211	0.837	0.810	1.510	1.231	1.201	1.317	1.6 (13)
6.219	0.839	0.810	1.765	1.480	1.359	1.558	2.2 (13)
6.228	0.838	0.815	2.016	1.580	1.500	1.802	3.0 (13)
6.240	0.839	0.816	2.249	1.780	1.789	2.035	3.7 (13)
6.212	0.839	0.816	2.305	1.882	1.937	2.083	4.4 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at $100^{o}F$

TABLE 3-69 RUN 3, FORWARD VOLTAGE CHARACTERISTICS (100°F) GE-92

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1*	2	3	4	
8.188	0.870	-	0.875	0.864	0.834	0.850	(1)
8.345	0.870	-	0.880	0.869	0.847	0.863	(2)
8.520	0.874	-	0.883	0.870	0.848	0.865	9.6 (9)
8.540	0.870	-	0.889	0.870	0.850	0.865	5.1 (10)
8.404	0.870	-	0.889	0.870	0.849	0.866	8.1 (10)
8.022	0.865	-	0.890	0.864	0.844	0.864	1.4 (11)
7.854	0.860	0.830	0.900	0.870	0.850	0.871	1.9 (11)
8.055	0.866	0.835	0.910	0.874	0.854	0.872	2.2 (11)
7.925	0.861	0.831	0.918	0.876	0.854	0.874	2.8 (11
8.231	0.870	0.840	0.934	0.895	0.870	0.890	3.3 (11)
7.990	0.868	0.841	0.970	0.910	0.880	0.909	4.7 (11)
7.982	0.860	0.840	1.005	0.932	0.905	0.930	6.1 (11)
8.160	0.852	0.841	1.114	0.999	0.969	0.999	2.8 (12)
8.097	0.869	0.841	1.170	1.035	1.006	1.040	5.3 (12)
8.080	0.859	0.840	1.256	1.085	1.057	1.095	8.2 (12)
8.090	0.855	0.841	1.495	1.233	1.194	1.252	1.4 (13)
8.008	0.862	0.840	1.718	1.382	1.346	1.425	1.9 (13)
8.098	0.870	0.840	2.070	1.611	1.576	1.695	2.7 (13)
8.069	0.870	0.842	2.342	1.826	1.820	1.965	3.4 (13)
7.782	0.868	0.840	2.476	2.000	2.053	2.219	4.4 (13)

(1) Pre Test at Ambient Temperature
(2) Pre Test at 100°F

TABLE 3-70 RUN 3, FORWARD VOLTAGE CHARACTERISTICS (160°F) GE-92

Forward Current (Amps)	Forward Voltage Drop (VDC)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	11	12	7*	8	9	10	
8.407	0.857	0.851	0.898	0.878	0.845	0.837	(1)
8.592	0.831	0.823	0.880	0.850	0.814	0.803	3.9 (10)
8.257	0.824	0.820	0.883	0.846	0.814	0.800	1.2 (11)
8.210	0.855	0.848	0.933	0.894	0.862	0.849	2.3 (11)
8.570	0.832	0.825	0.927	0.878	0.841	0.826	3.2 (11)
8.520	0.860	0.850	1.030	0.961	0.920	0.898	7.2 (11)
8.440	0.828	0.814	1.039	0.944	0.900	0.874	3.3 (11)

(1) Pre Test at Ambient Temperature

TABLE 3-71 RUN 4, REVERSE LEAKAGE CHARACTERISTICS (100°F) GE-92

Reverse Voltage (VDC)	Reverse Leakage (μA)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3	4	
49.7	1.649	0.842	1.249	1.992	1.262	1.069	(2)
49.7	1.722	0.852	1.355	2.101	1.372	1.148	1.1 (10)
49.7	1.407	0.752	1.302	1.962	1.312	1.072	4.1 (10)
49.7	1.601	0.842	1.542	2.412	1.452	1.198	5.2 (10)
49.7	1.691	0.832	1.612	2.501	1.532	1.248	7.4 (10)
49.7	1.682	0.842	1.741	7.682	1.612	1.301	1.1 (11)
49.7	1.612	0.802	1.832	2.809	1.681	1.309	1.4 (11)
49.7	1.401	0.701	1.651	2.502	1.542	1.201	1.7 (11)
49.7	2.211	1.071	3.252	4.801	2.702	2.012	2.4 (11)
49.7	2.601	1.232	4.401	6.141	3.509	2.479	3.0 (11)
49.7	1.701	0.849	4.229	5.701	3.592	2.601	4.0 (11)
49.7	1.662	0.782	4.311	5.001	3.376	2.301	5.0 (11)
49.7	1.099	0.885	5.802	7.189	4.335	2.999	5.9 (11)
49.7	1.851	0.872	6.832	8.008	4.853	3.207	6.9 (11)
49.7	1.832	0.882	10.812	13.642	7.099	5.012	5.6 (12)
49.7	1.591	0.659	FS	FS	66.109	44.169	4.4 (13)

Pre Test at 100°F

TABLE 3-72 RUN 5, REVERSE LEAKAGE CHARACTERISTICS (100°F) GE-92

Reverse Voltage (VDC)	Reverse Leakage (μA)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3	4	
99.3	2.399	2.051	2.052	2.342	1.668	1.741	9.3 (8)
99.2	2.452	2.012	2.004	2.511	1.819	1.893	1.3 (10)
99.2	2.312	2.002	2.252	2.641	1.842	1.801	4.4 (10)
99.2	2.356	2.022	2.402	2.832	1.902	1.902	5.3 (10)
99.2	2.372	2.012	2.572	3.059	2.077	2.042	9.0 (10)
99.2	2.369	1.919	2.742	3.272	2.007	2.072	1.2 (11)
99.2	2.401	2.001	3.077	3.749	2.416	2.272	1.5 (11)
99.2	2.419	2.058	3.552	4.331	2.742	2.532	1.9 (11)
99.2	3.202	2.342	4.903	5.962	3.601	3.308	2.5 (11)
99.2	3.601	2.652	6.312	7.542	4.631	4.071	3.0 (11)
99.2	2.313	1.802	5.602	6.502	4.102	3.632	4.8 (11)
99.2	2.582	2.002	7.832	8.902	5.489	4.572	6.0 (11)
99.2	2.519	1.962	15.079	18.001	10.042	7.799	6.0 (12)
99.2	-	-	200.09	240.19	86.09	43.99	4.4 (13)

TABLE 3-73 RUN 6, REVERSE LEAKAGE CHARACTERISTICS (100°F) GE-92

Reverse Leakage (VDC)	Reverse Leakage (μA)						Neutron Exposure (n/cm^2)
	Control Diodes		Irradiated Diodes				
	5	6	1	2	3	4*	
195.6	0.599	7.402	3.659	3.104	2.532	6.322	2.2 (9)
195.6	4.012	7.352	3.942	3.401	2.701	6.649	1.4 (10)
195.6	3.882	7.312	4.091	3.622	2.772	6.708	4.5 (10)
195.6	3.801	7.722	4.282	3.812	2.852	7.012	5.4 (10)
195.6	4.001	7.301	4.462	3.952	2.942	7.014	6.6 (10)
195.6	3.002	7.248	4.442	4.042	3.002	7.111	8.4 (10)
195.6	3.922	7.203	4.671	4.331	3.182	7.001	1.1 (11)
195.6	3.902	7.072	5.012	4.692	3.392	7.542	1.4 (11)
195.6	3.913	7.142	5.202	4.942	3.542	7.199	1.5 (11)
195.6	4.001	7.079	5.001	5.443	3.782	8.007	1.8 (11)
195.6	4.441	7.522	6.232	6.101	4.242	8.069	2.0 (11)
195.6	5.039	7.629	8.132	8.202	5.402	9.724	2.5 (11)
195.6	5.501	8.009	9.602	9.701	6.302	10.602	3.0 (11)
195.6	6.012	8.108	11.012	11.001	7.141	11.504	4.7 (11)
195.6	4.051	6.641	10.232	10.442	6.802	10.202	5.4 (11)
195.7	4.142	6.702	11.003	11.002	7.149	10.432	5.7 (11)
195.6	4.202	6.767	17.119	12.601	7.829	11.012	6.4 (11)
195.6	4.452	6.922	15.299	16.203	9.782	12.411	1.1 (12)
195.7	4.342	6.742	16.792	17.512	10.401	12.842	2.1 (12)
195.7	4.201	6.859	18.109	19.182	11.303	13.049	3.1 (12)
195.7	4.142	6.742	23.042	25.682	14.507	15.699	6.6 (12)
195.7	4.232	6.912	29.342	37.801	18.001	18.049	8.6 (12)
195.7	4.142	6.912	40.039	50.802	77.041	25.462	1.7 (13)
195.7	-	4.39	60.12	67.64	30.39	30.00	1.6 (13)
195.7	-	-	130.03	145.79	58.00	45.99	2.5 (13)
195.7	-	-	220.04	250.49	90.07	74.99	3.2 (13)
195.7	-	-	119.99	320.39	115.09	-	3.6 (13)
195.7	-	-	359.99	403.01	100.06	110.95	4.0 (13)

3.4 CAPACITORS AND RESISTORS

The capacitors and resistors showed no change due to irradiation in either the 160°F or 100°F irradiation. A small effect due to temperature was evident. Representative capacitor data are tabulated in Tables 3-74 thru 3-77. The resistor data are tabulated in Tables 3-75 and 3-77. The instrumentation used for these tests is shown in Figure 1-8.

The 400 cycle stressing voltage of 485 volts coupled into the capacity bridge caused a decrease in the bridge sensitivity at times. The data tables reflect this and it is noticeable by the fewer number of digits in the dissipation factor. The data spread of the capacity measurements is approximately .04% for the C1 capacitors and .07% for the C2 capacitors with the 400 cycle coupling considered. The dissipation factor data spread is approximately 6% for the C1 capacitors and 5% for the C2 capacitors. All measurements were made at 1 KC. Checks at 400 cps indicated the same values but measurements were affected by beats between the different 400 cycle sources.

The accuracy of the resistor measurements was affected by the short term stability of the power supplies. The data indicates the presence of drift, however, it is small and in the order of 0.1%.

TABLE 3-74 CAPACITORS C1 AND C2 AT 160°F

Capacitor C1 (10CPM-174) 160°F at 1 KC Nominal .17 μf												
C1-7		C1-8		C1-9		C1-10		C1-11		C1-12		Elapsed Time @ 160°F
C	DF	C	DF	C	DF	C	DF	C	DF	C	DF	
170032	.004541	170140	.004465	170191	.004500	170144	.004565	170139	.004510	170140	.004500	Amb. Temp.
170410	.004897	170440	.004999	170374	.004800	170420	.004800	170350	.004800	170332	.004800	15 H
170370	.0052	170400	.0053	170380	.00477	170350	.0054	170320	.005	170307	.00483	29 H
170354	.0050	170444	.00499	170380	.00482	170340	.0052	170340	.00499	170300	.00484	39 H
170340	.0052	170450	.0051	170380	.0048	170420	.0053	170300	.0048	170300	.0049	54 H
170364	.00502	170465	.004991	170374	.00477	170374	.005010	170246	.004720	170263	.00474	68 H

Total Exposure 1.3 (12) n/cm^2 and 4.4 (6) Rads - Cap. in Pf; DF in %.

Capictor C2 (GE-89) 160°F at 1 KC Nominal .0062 μf												
C2-7		C2-8		C2-9		C2-10		C2-11		C2-12		Elapsed Time @160°
C	DF	C	DF	C	DF	C	DF	C	DF	C	DF	
6233.3	.000720	6470.10	.000721	6128.53	.000721	6462.53	.000740	6298.00	.000900	6506.00	.000995	Amb. Temp.
6265.57	.000899	6503.32	.000870	6159.80	.000860	6495.40	.000899	6327.60	.000900	6534.40	.000896	15 H
6266.70	.00089	6504.72	.000883	6161.20	.00088	6500.00	.00084	6328.40	.00088	6536.23	.000905	29 H
6264.63	.000865	6502.76	.000872	6159.34	.000864	6494.74	.000893	6330.23	.000895	6538.54	.000905	39 H
6266.91	.000900	6505.15	.000890	6161.54	.000885	6496.60	.000915	6328.06	.000885	6535.70	.000900	54 H
6262.76	.000862	6500.69	.000852	6157.18	.000846	6492.12	.000872	6327.40	.000852	6531.32	.000866	68 H

Total Exposure 9.34 (11) n/cm^2 and 2.9 (6) Rads - Cap in Pf; DF in %.

TABLE 3-75 RESISTORS R1 AND R2 AT 160°F

Resistor R1 (GE-86) 160°F Nominal 1000 Ω						
R1-7	R1-8	R1-9	R1-10	R1-11	R1-12	Elapsed Time @ 160°
936.2	930.5	937.0	931.5	931.2	938.8	Amb. Temp.
936.0	930.1	936.5	931.0	930.6	938.3	15 H 30'
935.7	929.6	936.0	930.5	930.0	937.6	29 H 30'
936.0	930.0	936.4	930.9	930.5	938.1	39 H 30'
936.0	930.0	936.3	930.8	930.4	938.0	53 H 30'
936.3	930.4	937.0	931.6	931.3	938.9	67 H

Total Exposure 9.34 (11) n/cm^2 and 2.9 (6) Rads - R in ohms.

Resistor R2 (GE-87) 160°F Nominal 698KΩ						
R2-7	R2-8	R2-9	R2-10	R2-11	R2-12	Elapsed Time @ 160°F
695.77	696.07	695.95	695.53	698.35	698.14	Amb. Temp.
698.23	695.77	695.46	695.14	698.17	697.27	16 H
695.22	696.13	695.56	695.43	698.35	697.30	33 H
695.03	695.77	695.52	694.97	698.30	696.85	41 H
694.60	695.22	694.87	694.87	697.65	696.95	57 H
695.38	695.80	695.68	695.62	698.35	697.05	70 H

Total Exposure 9.34 (11) n/cm^2 and 2.9 (6) Rads - R (-3) ohms.

TABLE 3-76 CAPACITORS C1 AND C2 AT 100°F

Capacitor C1 (10CPM-174) 100°F Nominal .17 μf												
C1-1		C1-2		C1-3		C1-4		C1-5		C1-6		Elapsed Time @ 100°F
C	DF	C	DF	C	DF	C	DF	C	DF	C	DF	
170100	.0046	170100	.0049	170105	.0049	170100	.00459	170000	.0045	170070	.00459	Amb. Temp
170187	.00482	170100	.005	170150	.0049	170135	.0047	170100	.0046	170130	.0046	1 H
170170	.0047	17021	.005	17020	.0049	17018	.0047	170083	.0046	170150	.0047	17 H
170190	.0049	170200	.005	17020	.0049	17019	.0047	17009	.005	17013	.0047	29 H
17019	.0049	17020	.005	17020	.0049	17020	.0049	17010	.005	17012	.0048	62 H

Total Exposure 8.2 (13) n/cm^2 and 7.2 (6) Rads - Cap. in Pf and DF in %.

Capacitor C2 (GE-89) 100°F Nominal .0062 μf												
C2-1		C2-2		C2-3		C2-4		C2-5		C2-6		Elapsed Time @ 100°F
C	DF	C	DF	C	DF	C	DF	C	DF	C	DF	
6201.45	.000778	6403.54	.000743	6334.82	.000830	6291.66	.000763	6496.30	.000742	6369.51	.000747	Amb. Temp.
6207.20	.000771	6409.41	.000743	6340.00	.000839	6296.87	.000765	6504.00	.00074	6376.75	.000766	1 H
6209.51	.000776	6411.80	.00078	6341.80	.00079	6299.42	.00078	6504.65	.00079	6377.70	.00078	17 H
6210.9	.00079	6413.3	.0008	6343.2	.0008	6300.6	.00079	6505.4	.0008	6378.5	.00079	29 H
6210.9	.00079	6413.4	.00079	6343.5	.0008	6301.2	.00079	6504.0	.0008	6377.2	.00079	62 H

Total Exposure 4.4 (13) n/cm^2 and 4.7 (6) Rads - Cap. in Pf and DF in %.

TABLE 3-77 RESISTORS R1 AND R2 AT 100°F

Resistor R1 (GE-86) 100°F Nominal 1000 Ω						
R1-1	R1-2	R1-3	R1-4	R1-5	R1-6	Elapsed Time @ 100°F
936.0	936.3	931.4	931.0	936.7	930.8	Amb. Temp.
935.9	936.1	931.1	930.6	936.2	930.3	4 H
936.1	936.4	931.6	931.2	936.7	930.9	18 H
935.9	936.1	931.2	930.6	936.3	930.4	43 H 30'
936.7	937.0	932.3	931.8	937.6	931.8	62 H 30'

Total Exposure 4.4 (13) n/cm^2 and 4.7 (6) Rads - R in ohms

Resistors R2 (GE-87) 100°F Nonimal 698 K Ω						
R2-1	R2-2	R2-3	R2-4	R2-5	R2-6	Elapsed Time @ 100°F
696.50	698.33	696.96	696.24	696.36	696.50	Amb. Temp.
696.36	698.23	696.95	696.08	696.16	696.22	4 H 00'
696.40	698.35	696.95	696.16	696.46	696.36	17H 20'
695.77	697.44	696.29	695.36	695.91	695.93	45 H 30'
696.23	698.02	696.57	695.84	696.01	696.04	61 H 40'

Total Exposure 4.4 (13) n/cm^2 and 4.7 (6) Rads - R (-3) ohms

4.0 SUBASSEMBLIES

The initial phase of the test was devoted to checkout of each subassembly test panel. This check was both visual and operational. Each subassembly test pan el was set up in the laboratory and the input varied to assure no shipping damage had been incurred and to establish agreement with AGC bench test data. The null or a representative operational point was recorded for each subassembly test panel. A complete set of data were recorded for one test panel of each type of subassembly. These pre-test bench data are included in the tables. The voltage divider and shunts were checked out to determine circuit load effect. Precision components were purchased or fabricated for this application.

During the visual examination some shipping damage was found on the 8 Diode Frequency Sensing subassemblies. The mounting of the two inductors had broken allowing the coils to bounce free. The glass wrapping tape was chaffed and worn through on a number of test items. The mounting was redesigned and replaced on all twelve 8 Diode test panels. The more severly damaged subassemblies had wire exposed to bright copper. A coil on SCR Trigger #3 was found to be open. A new coil was received from Aerojet and installed. Numerous screws were also either loose or missing and several insulators and terminal strips were broken. These were replaced as needed and the screws tightened.

The base plate of most test items was trimmed approximately 1/8" on all sides to reduce the overall size of the test package. This was necessary to keep the test in the shadow of the lithium hydride shield.

The voltage dividers that had been selected were installed in aluminum boxes and attached to the cables near the pit end so that they would be shielded from irradiation by the pit wall and protected from ambient temperature changes.

Voltage dividers and current shunts were accurately calibrated before and after the tests. Actual values were sufficiently close to nominal to permit the nominal values to be used in data reduction and with negligible error.

The receiving inspection checkout revealed that two of the 8 Diode frequency sensing units were damaged in shipment. To preclude any possibility of these units contributing to false indications of radiation effects, they were used as control items and assigned as previously control items were used as radiation test specimens. The test panels were then wired, the cabling continuity checked and the test moved to the reactor building.

The checkout at the reactor building revealed that wave shapes of almost all the subassemblies did not agree with ben ch test data at GNL and Aerojet. When normal trouble-shooting measures did not clear the problems, the test car was moved back to the REL for a complete checkout. The cabling was again continuity checked and a few minor errors found, however, these were not adequate to explain all the difficulties that had been encountered at the REF. Each subassembly was operated in turn through its cable and the characteristics checked. Each unit showed normal operating characteristics. The test car was moved back to the reactor building and reconnected to the instrumentation cabling.

During the initial setup and checkout period the automatic data system has been stepped manually from one unit to another. Under this condition the automatic system operated normally, however, when the switching was performed automatically at two seconds per point, the time response of the subassemblies proved too slow to allow switching from a set stressing condition to a measuring condition as had originally been planned. The switching as described in paragraph 3.2.1 of the Design Manual was, therefore, modified. The operational procedure was changed to allow the stressing condition to be set to the values for which the measurements were made. The circuit diagrams in the design manual were revised to reflect this change. (Reference Figures 3-7 and 3-8.)

During this checkout period it was determined that the cable capacitance to ground of each of the instrumentation points was the primary cause of the difficulties which had been encountered. The capacitances, in order of .01 μf for the 300 foot section, caused extensive couplings throughout the system, and changed the operating characteristics of the circuits. To eliminate or minimize the effects of cable capacitance to ground, the following changes were made:

4 Diode Frequency Sensing Circuit, ref. Design Manual Figure 3.7, four 1.2 megohm resistors were added, see Figure 4-7 -

Between Points A and V 1
Points C and V 3
Points J and V2
Points G and V 4

8 Diode Frequency Sensing Circuit, Figure 4-12. Similar changes were tried on the 8 Diode Frequency Sensing units as had been employed on the 4 Diode units but little improvement was observed. The following changes were made on one panel (Serial 8 only). Add four 1.5 megohm resistors -

Between Points A and V 1
Points C and V 3
Points J and V 2
Points G and V 4

Voltage Sensing Circuit, Figure 4-1 -

Delete the 3K ohm resistor from voltage divider for V 1. Note: The 3.6 megohm resistor was left in the circuit to isolate point F from the instrumentation cable capacitance. Oscilliscope pictures, Figure 4-6, show normal wave shapes in place at the REF.

Magnetic Amplifier and SCR Control and Trigger Circuits, Figures 4-16 and 4-19. A 2.5 μf capacitor was added in parallel to each inductor in the load of these units to reduce the effect of the noise.

The 160°F irradiation test divided the time equally between manual and automatic data systems. The correlation found between the data taken on the backup panel and the automatic data system proved to be good and since the automatic system was much faster, it was decided to take the majority of the 100°F data on the automatic system. The change in procedure permitted additional points to be monitored completely mapping the operating characteristics of all subassemblies. The following tables should replace the tabulation shown at the top of page 25 of the design manual for the 100°F run.

SCR Panels, ref. Design Manual Section 3-11

The SCR panels were extremely noisy and sensitive to pickup. Satisfactory data could be obtained on them only when they operated individually. The procedure was changed accordingly.

SCR D/L Mv
2.0
4.0
5.0
6.0
7.0
7.5
8.0
8.5

One at a time.

VS and MA panels off.

Set voltage on Var. #2, 208 V.

Read I_2 on millivac and type into Flexowriter.

Return SCR, VS and MA to normal voltage.

100^{o}F Run

4D Frequency Sensing Period x 10^6 Sec.	8D Frequency Sensing Period x 10^6 Sec.	Mag. Amp. (D/L Mv)	VS
2400	2350	1.0	190
2430	2400	1.5	196
2450	2450	2.0	200
2470	2500	2.5	206
2480	2550	3.0	210
2490	2600	3.5	216
2500		6.0	220
2510		9.0	226
2520		Between runs set to approx. 2 mv	Between runs set at approx. 208 V
2530			
2550			
2570			
2600			
Between runs set to 2500 and 120 V			

The total dose for each subassembly is shown in Tables 4-39, 4-78, 4-118, 4-128, 4-132 and 4-135.

4.1 VOLTAGE SENSING

The output of the voltage sensing units was not affected at 2×10^{11} n/cm^2. There was a slight trend at the end of the 160^{o}F run and at an equivalent dose on the 100^{o}F run. There were no differences in the effects seen between the 100^{o}F and 160^{o}F tests at equal doses. Changes in circuit performance were due to increased forward drops in the 1N547 diodes used in this circuit. Figure 4-6 shows the saturable reactor voltage and diode CR 1 voltage for VS #8 at pre-test, just prior to 2×10^{11} n/cm^2 and at greater than 2×10^{11} n/cm^2 exposure. No change in wave form can be noted.

At the conclusion of the 100°F run changes in the diodes had caused noticeable changes in the output of each half of the voltage sensing circuit. However, the differential voltage, V6, was very nearly the same magnitude. The plot of Unit #1, shown in Figure 4-3, shows a shift in null. A change of approximately 4 volts in null voltages is believed to be caused by an unbalance in the four diodes in the circuit. Figure 4-4 is a plot of the forward voltage characteristics of each of the diodes removed from the unit. It is evident that Diode #2 was affected much more than the other three.

The differential voltage, V6, in Figure 4-3 shows a rather wide variation. Data tabulated for the control units show a similar variation. This variation is likely an accumulation of tolerances in the measurements rather than changes in sub-assembly operation. With an accuracy of ± .5% for the voltage recording of each half, a variation of differential voltage of approximately ± .25 volts could be expected. The voltages recorded for each half (V4 and V5) are of sufficient accuracy to show any changes that occurred due to irradiation. An adequate number of data points were obtained to ascertain the null shifts. Tables 4-3 thru 4-38 show complete sets of these data at selected radiation exposures.

Data from the bench test tests are included in Tables 4-1 and 4-2. These data include the null voltage for all units prior to test. During the post test a short circuit destroyed the diodes of VS #1. VS #2 was used for post test investigations.

Comparison of pre- and post-irradiation bench test data shows changes in output and null of the same order as that taken at the reactor, however, the absolute magnitudes were slightly different. The difference was due to the load dependancy of the circuit. The load across the differential output was varied during the post irradiation bench tests and it was found that the null could be shifted from 207 to 204 volts by changing the load resistance from 140 to 200 ohms. The actual load resistance under irradiation test conditions was greater than in the laboratory because of the additional line resistance present at the REF. Replacement of the four diodes in an irradiated unit with diodes removed from a control unit restored the null to the pre-irradiation value.

The cause of the null shifts can be seen clearly in Figure 4-2. The output from the side without the saturable reactor is approximately a straight line as is shown Curve 1. The output from the side with the saturable reactor is shown in Curve 2. The output of this side would be low until the reactor saturates at which time, because of the greater turns ratio, it would begin to rise at a greater slope than for the other side. The intersection of these two curves is the null point. If the voltage drop of the diodes increases rapidly with forward current the output from each half will deviate from the original line as shown in Curves 3 and 4. When the diode drops become unequal, as occurred during irradiation, one side will have an appreciably higher voltage drop than the other causing the intersection of the two lines to shift. The shift will be a lower voltage if the losses increase in Side 1 and a higher voltage if Side 2 losses increase. While this conclusion appears to be perfectly sound, additional tests will be run in which the diodes in the two sides will be interchanged and measurements made to verify the null shifts. Results of this test will be included in a supplemental report.

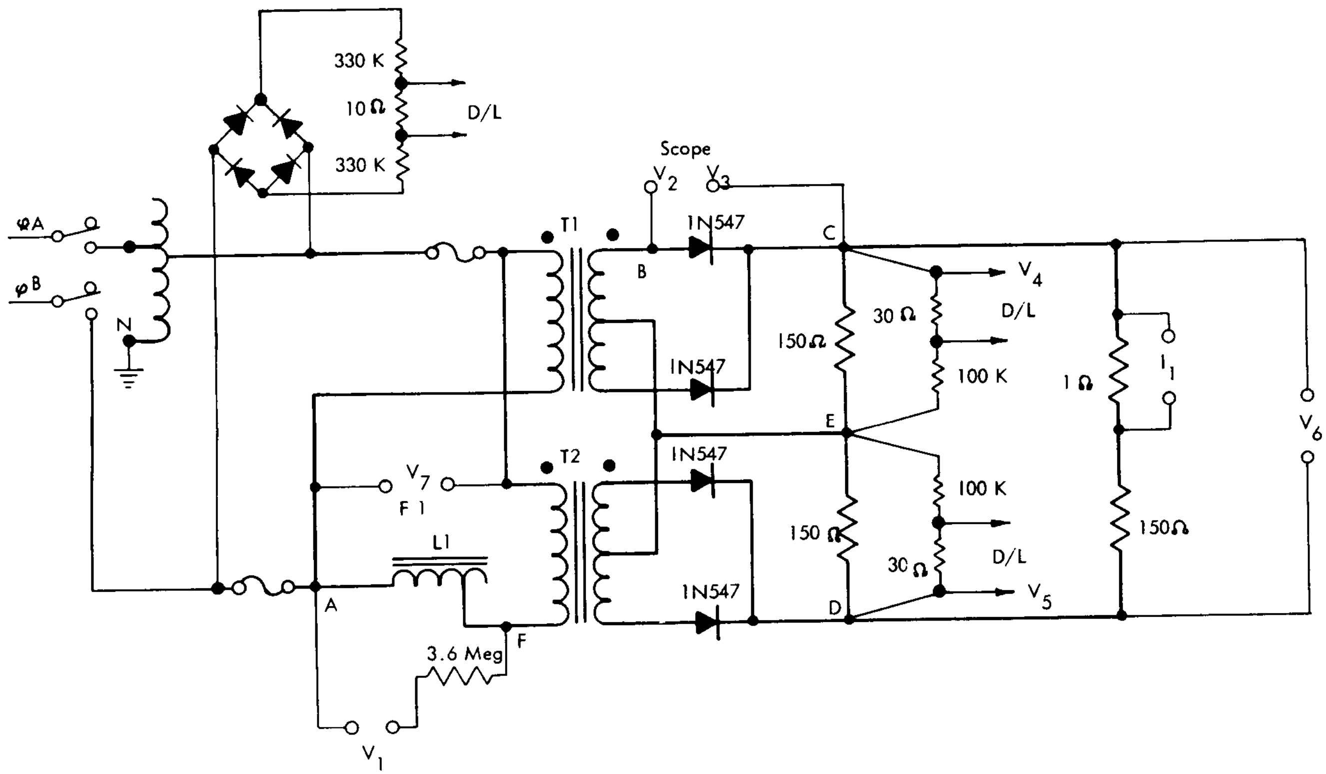


FIGURE 4 - 1 VOLTAGE SENSING

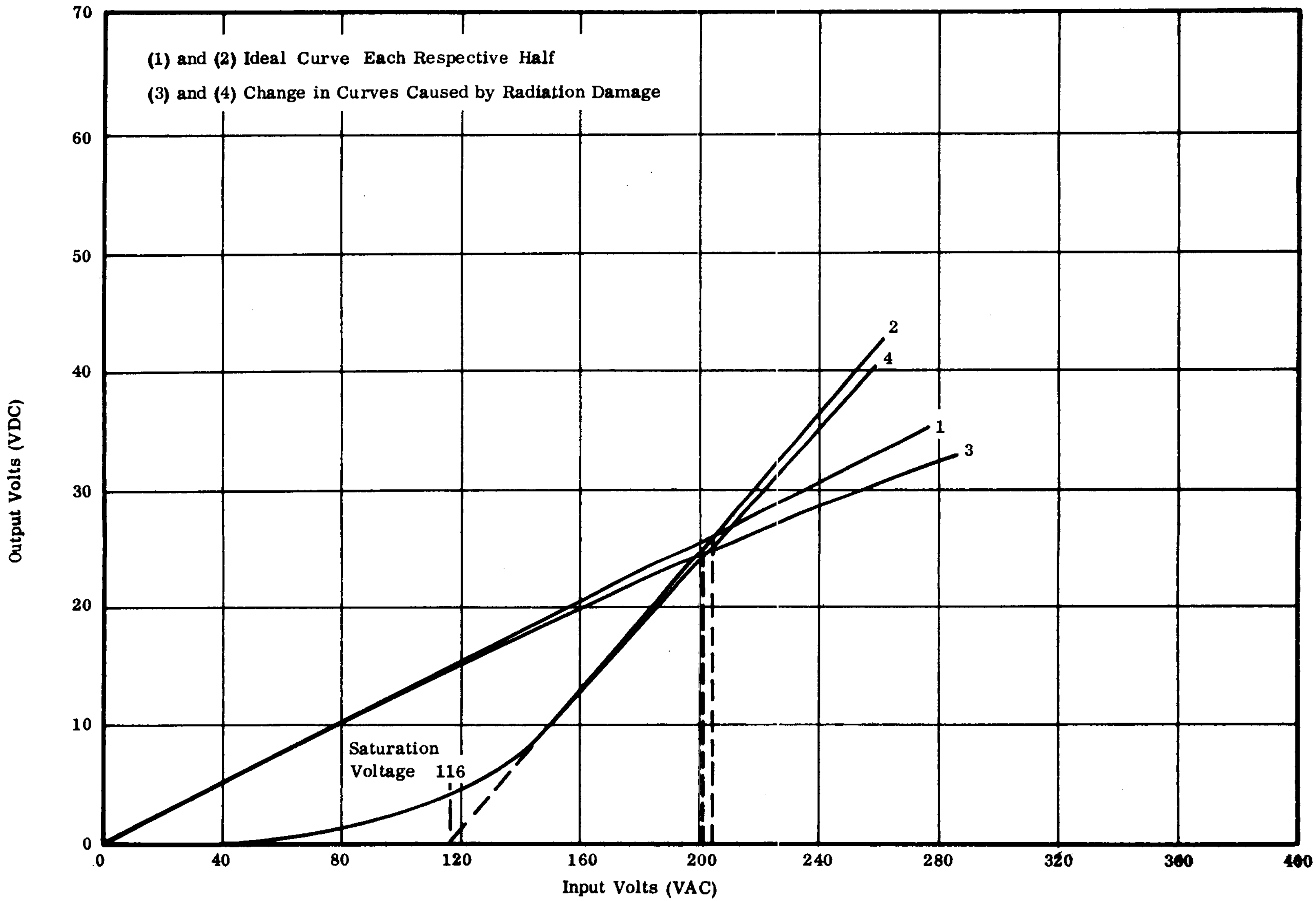


FIGURE 4-2 POSTULATED VARIATION IN NULL SHIFT OF VOLTAGE SENSING UNIT

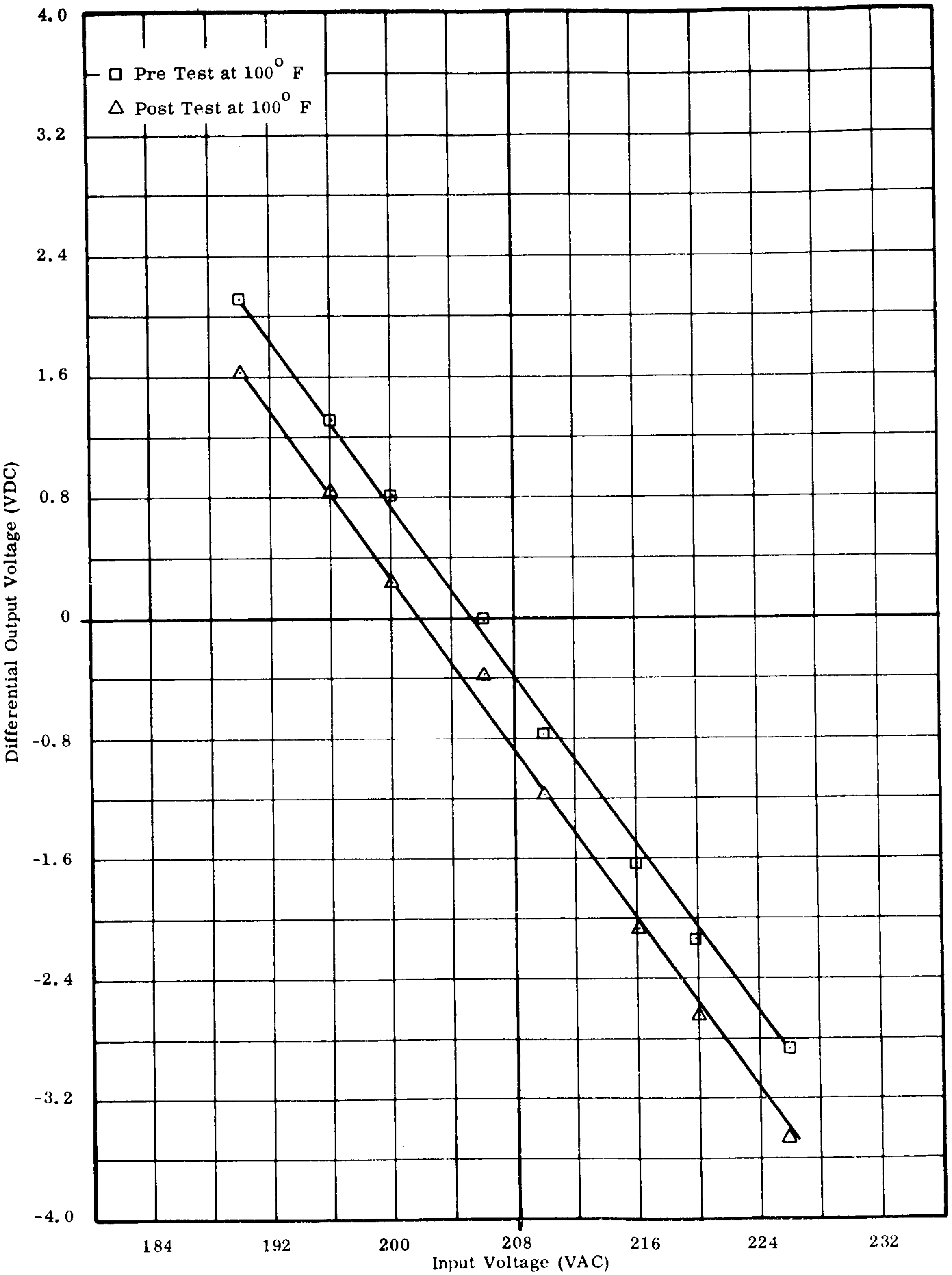


FIGURE 4-3 INPUT VOLTAGE VERSUS DIFFERENTIAL OUTPUT VOLTAGE, PRE AND POST MEASUREMENTS AT REACTOR FACILITY VOLTAGE SENSOR, SN#A-1

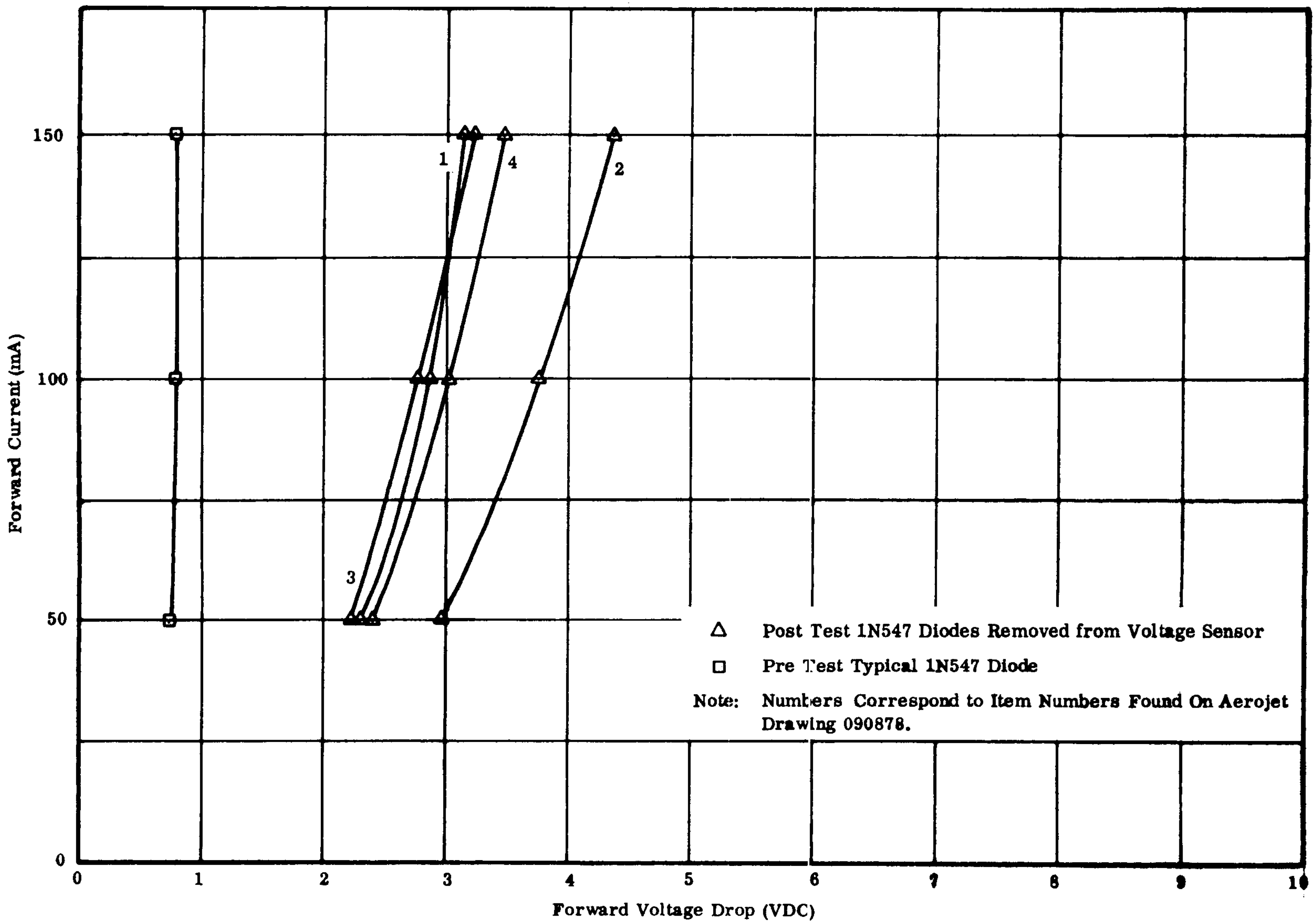
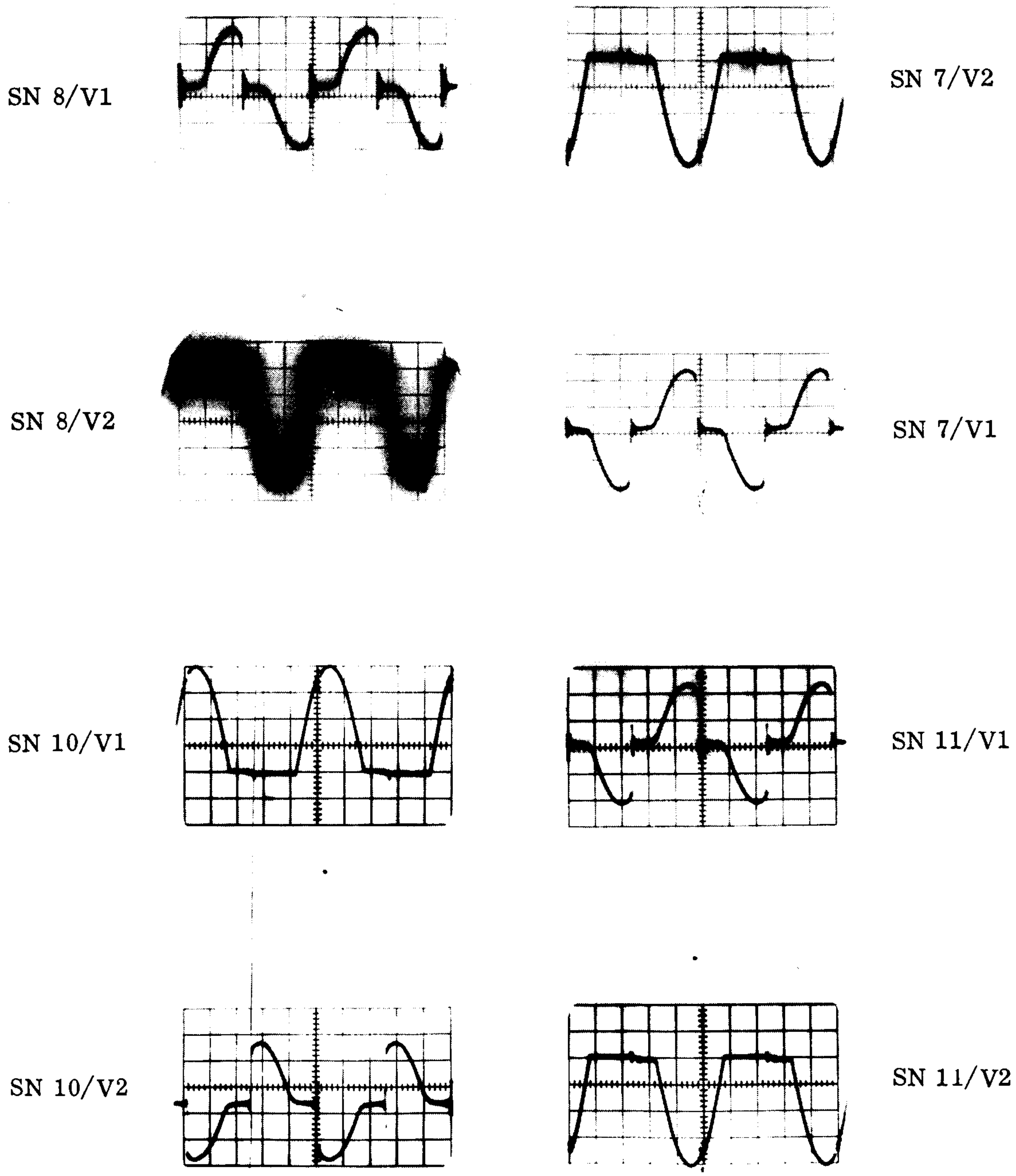


FIGURE 4-4 FORWARD CHARACTERISTICS, POST TEST (100° F), 1N547, REMOVED FROM VOLTAGE SENSOR #1, SN#A1

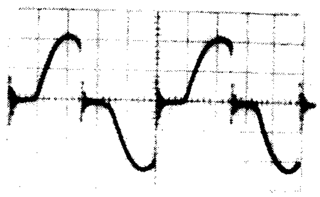
Date: 7/6/64
Time: Pre-Irradiation
Input Voltage: 212 Vac



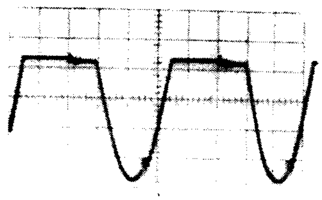
Sweep Speed: .5 m sec/cm
Gain: V1 = 100 V/cm
V2 = 20 V/cm

FIGURE 4 - 5 CHECK-OUT WAVE SHAPES ON VOLTAGE SENSING UNIT

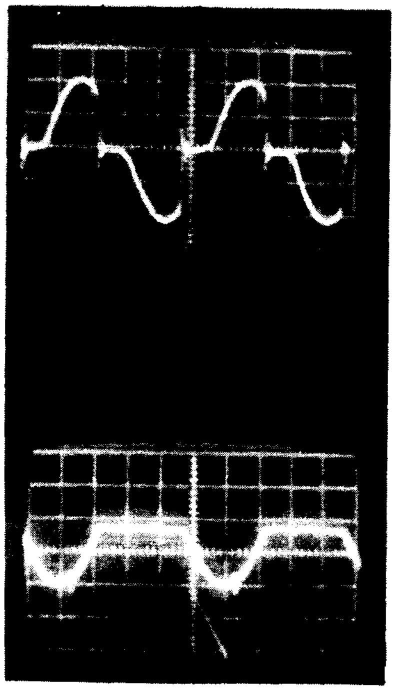
Date: 7/7/64
Time: 1920 Hours



SN 8/V1
Gain: 100 V/cm



SN 8/V2
Gain: 20 V/cm



SN 8/V1
Gain: 100 V/cm

SN 8/V2
Gain: 50 V/cm

Sweep Speed: .5 m sec/cm

FIGURE 4 - 6 VOLTAGE SENSING UNIT WAVE SHAPES DURING 160°F IRRADIATION

TABLE 4-1 FUNCTIONAL PRE-TEST AT LABORATORY
VOLTAGE SENSING UNIT

S/N	V7 at Null (VAC)	V4 at Null (VDC)
A1	209.2	26.2
A2	210.0	26.5
A3	210.0	27.6
A4	212.0	26.9
A5	210.0	27.9
A6	209.0	27.4
A7	208.0	27.1
A8	210.0	27.5
A9	210.0	26.5
A10	206.5	27.0
A11	210.0	27.3
A12	210.0	26.5

TABLE 4-2 POST TEST DATA, VOLTAGE SENSING UNIT MODEL 091376-1-C S/N A2

Input Volts (VAC)	Output Current (MA DC) I_1		V4 (VDC)		V5 (VDC)		Reactor (VAC)	
	Before	After	Before	After	Before	After	Before	After
188	-15.5	-21.0	20.70	23.28	18.42	20.14	126	126
190	-13.0	-19.0	20.98	23.58	19.05	20.75		
192	-11.5	-17.0	21.23	23.88	19.50	21.36		
194	-9.6	-15.0	21.51	24.16	20.08	21.91		
196	-7.8	-13.0	21.78	24.42	20.61	22.47		
198	-6.0	-11.0	22.05	24.70	21.15	23.04		
200	-4.5	-9.0	22.29	25.00	21.62	23.63	131	131
202	-2.6	-7.4	22.56	25.22	22.17	24.09		
204	-1.2	-5.4	22.79	25.53	22.61	24.70		
206	0.8	-3.7	23.04	25.79	23.15	25.23	133	
208	3.2	-1.8	23.26	26.08	23.73	25.80		
210	4.7	0.0	23.50	26.34	24.20	26.35		134
212	6.5	2.4	23.79	26.64	24.79	26.98		
214	8.0	3.9	24.03	26.89	25.22	27.47		
216	9.9	6.1	24.32	27.18	25.80	28.09		
218	11.5	7.8	24.55	27.44	26.24	28.61		
220	13.0	9.9	24.80	27.74	26.75	29.26		
222	15.0	12.0	25.10	28.00	27.33	29.73		
224	16.5	14.0	25.39	28.27	27.88	30.30	138	138

Before - Unit with Irradiated Diodes

After - Unit with S/N A-12 Diodes Substituted

TABLE 4-3 VOLTAGE SENSING S/N 1 PRE-TEST AT 100°F

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
2152	190	23.37	21.27	2.100
2156	196	24.24	22.94	1.300
2200	200	24.70	23.90	.800
2203	206	25.64	25.81	-.167
2207	210	26.31	27.07	-.767
2210	216	27.04	28.67	-1.634
2214	220	27.71	29.84	-2.134
2218	226	28.44	31.31	-2.867

TABLE 4-4 VOLTAGE SENSING S/N 1 AT END OF LOW POWER RUN

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
2315	190	23.14	20.97	2.167
2318	196	24.10	22.97	1.134
2322	200	24.74	24.24	.500
2326	206	25.57	25.97	-.400
2330	210	26.21	27.24	-1.034
2335	216	26.97	28.81	-1.834
2339	220	27.57	29.97	-2.400
2342	226	28.51	31.91	-3.401

Neutron Exposure 3.2 (11) nvt
Gamma Dose 1.44 (6) Rads

TABLE 4-5 SENSING S/N 1 AT END OF TEST WITH LiH SHIELD

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
1616	190	23.30	21.44	1.867
1619	196	24.07	23.07	1.000
1623	200	24.67	24.24	.433
1626	206	25.57	26.04	-.467
1630	210	26.14	27.14	-1.000
1633	216	27.01	28.87	-1.867
1637	220	27.54	29.91	-2.367
1641	226	28.57	31.94	-3.367

Neutron Exposure 7.5 (11) nvt
Gamma Dose 2.13 (6) Rads

TABLE 4-6 VOLTAGE SENSING S/N 1 POST-TEST AT 100°F

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
0927	190	21.60	19.97	1.634
0932	196	22.40	21.57	.833
0936	200	23.04	22.80	.233
0941	206	23.70	24.07	-.367
0948	210	24.47	25.64	-1.167
0953	216	25.24	27.31	-2.067
0957	220	25.81	28.44	-2.634
1001	226	26.74	30.21	-3.467

Neutron Exposure 4.4 (13) nvt
Gamma Dose 3.4 (6) Rads

TABLE 4-7 VOLTAGE SENSING S/N 2 PRE-TEST AT 100°F

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
2152	190	23.47	21.30	2.167
2156	196	24.34	22.94	1.400
2200	200	24.87	23.90	.967
2203	206	25.81	25.81	0.0
2207	210	26.47	27.07	-.600
2210	216	27.17	28.67	-1.500
2214	220	27.84	29.81	-1.967
2218	226	28.54	31.31	-2.767

TABLE 4-8 VOLTAGE SENSING S/N 2 AT END OF LOW POWER RUN

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
2315	190	23.24	21.00	2.234
2318	196	24.27	22.97	1.300
2322	200	24.87	24.30	.567
2326	206	25.64	25.97	-.333
2330	210	26.34	27.34	-1.000
2335	216	27.14	28.87	-1.734
2339	220	27.67	29.97	-2.300
2342	226	28.64	31.94	-3.301

Neutron Exposure 3.2 (11) nvt
Gamma Dose 1.27 (6) Rads

TABLE 4-9 VOLTAGE SENSING S/N 2 AT END OF TEST WITH LiH SHIELD

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
1616	190	23.40	21.47	1.934
1619	196	24.24	23.04	1.200
1623	200	24.80	24.27	.533
1626	206	25.71	26.04	-.333
1630	210	26.27	27.17	-.900
1633	216	27.14	28.94	-1.800
1637	220	27.67	29.94	-2.267
1641	226	28.74	31.97	-3.234

Neutron Exposure 7.5 (17) nvt
Gamma Dose 1.87 (6) Rads

TABLE 4-10 VOLTAGE SENSING S/N 2 POST-TEST AT 100°F

Time	Input Voltage Volts RMS	Output dc Volts Half Output V4	Half Output V5	Differential Output V6
0927	190	21.80	19.70	2.100
0932	196	22.64	21.30	1.334
0936	200	23.24	22.44	.800
0941	206	23.94	23.90	.033
0948	210	24.64	25.24	-.600
0953	216	25.44	26.97	-1.534
0957	220	26.01	28.07	-2.067
1001	226	26.97	29.81	-2.834

Neutron Exposure 4.4 (13) nvt
Gamma Dose 3.0 (6) Rads

TABLE 4-11 VOLTAGE SENSING S/N 3 PRE-TEST AT 100°F

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
2152	190	23.37	20.90	2.467
2157	196	24.24	22.57	1.667
2200	200	24.70	23.50	1.200
2204	206	25.64	25.44	.200
2207	210	26.31	26.64	-.333
2211	216	27.01	28.27	-1.267
2215	220	27.64	29.41	-1.767
2218	226	28.47	21.04	-2.567

TABLE 4-12 VOLTAGE SENSING S/N 3 AT END OF LOW POWER RUN

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
2315	190	23.14	20.60	2.534
2318	196	24.14	22.70	1.434
2322	200	24.77	23.90	.867
2326	206	25.57	25.64	-.067
2331	210	26.21	26.81	-.600
2336	216	27.01	28.47	-1.467
2339	220	27.54	29.61	-2.067
2342	226	28.51	31.51	-3.001

Neutron Exposure 4.27 (11) nvt
Gamma Dose 2.59 (6) Rads

TABLE 4-13 VOLTAGE SENSING S/N 3 AT END OF TEST WITH LiH SHIELD

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
1616	190	23.27	21.10	2.167
1619	196	24.07	22.67	1.400
1623	200	24.67	23.90	.767
1627	206	25.57	25.64	-.067
1630	210	26.14	26.77	-.633
1633	216	27.01	28.54	-1.534
1637	220	27.54	29.51	-1.967
1641	226	28.54	31.57	-3.034

Neutron Exposure 1.0 (12) nvt
Gamma Dose 3.8 (6) Rads

TABLE 4-14 VOLTAGE SENSING S/N 3 POST-TEST AT 100°F

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
0927	190	20.50	18.44	2.067
0932	196	21.30	19.94	1.367
0936	200	21.87	21.04	.833
0942	206	22.64	22.44	.200
0948	210	23.27	23.77	-.500
0953	216	24.07	25.41	-1.334
0957	220	24.64	26.44	-1.800
1001	226	25.61	28.14	-2.534

Neutron Exposure 6.3 (13) nvt
Gamma Dose 6.1 (6) Rads

TABLE 4-15 VOLTAGE SENSING S/N 4 PRE-TEST AT 100°F

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
2152	190	23.47	21.30	2.167
2157	196	24.37	22.97	1.400
2200	200	24.84	23.94	.900
2204	206	25.81	25.87	-.067
2207	210	26.47	27.07	-.600
2211	216	27.14	28.67	-1.534
2215	220	27.84	29.81	-1.967
2218	226	28.64	31.34	-2.701

TABLE 4-16 VOLTAGE SENSING S/N 4 AT END OF LOW POWER RUN

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
2315	190	23.24	20.97	2.267
2318	196	24.27	23.04	1.234
2322	200	24.90	24.27	.633
2326	206	25.71	26.04	-.333
2331	210	26.31	27.24	-.933
2336	216	27.14	28.87	-1.734
2339	220	27.67	29.97	-2.300
2342	226	28.64	31.91	-3.267

Neutron Exposure 4.27 (11) nvt
Gamma Dose 2.59 (6) Rads

TABLE 4-17 VOLTAGE SENSING S/N 4 AT END OF TEST WITH LiH SHIELD

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
1616	190	23.40	21.47	1.934
1619	196	24.20	23.04	1.167
1623	200	24.80	24.30	.500
1627	206	25.71	26.04	-.333
1630	210	26.27	27.17	-.900
1633	216	27.14	28.91	-1.767
1637	220	27.64	29.94	-2.300
1641	226	28.71	31.97	-3.267

Neutron Exposure 1.0 (12) nvt
Gamma Dose 3.59 (6) Rads

TABLE 4-18 VOLTAGE SENSING S/N 4 POST-TEST AT 100°F

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
0927	190	20.57	19.10	1.467
0932	196	21.37	20.80	.567
0936	200	21.94	21.77	.167
0942	206	22.70	23.27	-.567
0948	210	23.37	24.57	-1.200
0953	216	24.17	26.14	-1.967
0957	220	24.74	27.24	-2.500
1001	226	25.64	29.04	-3.401

Neutron Exposure 6.3 (13) nvt
Gamma Dose 6.3 (6) Rads

TABLE 4-19 CONTROL VOLTAGE SENSING S/N 5 PRE-TEST AT 100°F

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
2152	190	23.37	21.34	2.034
2157	196	24.27	23.00	1.267
2200	200	24.77	24.00	.767
2204	206	25.74	25.97	-.233
2207	210	26.37	27.17	-.800
2211	216	27.07	28.74	-1.667
2215	220	27.67	29.81	-2.134
2218	226	28.47	31.41	-2.934

TABLE 4-20 CONTROL VOLTAGE SENSING S/N 5 POST-TEST AT 100°F

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
0927	190	23.57	21.40	2.167
0932	196	24.37	23.10	1.267
0936	200	24.97	24.27	.700
0942	206	25.77	25.81	-.033
0948	210	26.41	27.24	-.833
0953	216	27.21	28.91	-1.700
0957	220	27.77	30.11	-2.334
1001	226	28.67	31.91	-3.234

TABLE 4-21 CONTROL VOLTAGE SENSING S/N 6 PRE-TEST AT 100°F

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
2152	190	23.50	21.60	1.900
2157	196	24.37	23.20	1.167
2200	200	24.90	24.27	.633
2204	206	25.84	26.27	-.433
2207	210	26.47	27.47	-1.000
2211	216	27.14	28.97	-1.834
2215	220	27.81	30.01	-2.200
2218	226	28.67	31.67	-3.001

TABLE 4-22 CONTROL VOLTAGE SENSING S/N 6 POST-TEST AT 100°F

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
0927	190	23.64	21.64	2.000
0932	196	24.47	23.30	1.167
0936	200	25.07	24.50	.567
0942	206	25.84	26.07	-.233
0948	210	26.51	27.47	-.967
0953	216	27.31	29.17	-1.867
0957	220	27.91	30.37	-2.467
1001	226	28.81	32.21	-3.401

TABLE 4-23 VOLTAGE SENSING S/N 7 PRE-TEST AT 160°F

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
0154	196	23.97	23.60	.367
0157	212	26.44	28.41	-1.967
0201	220	27.47	30.74	-3.267

TABLE 4-24 VOLTAGE SENSING S/N 7 AT END OF LOW POWER RUN

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
1054	190	23.37	22.30	1.067
1058	195	24.17	23.90	2.667
1101	200	24.87	25.34	-4.668
1105	204	25.37	26.44	-1.067
1109	208	26.07	27.74	-1.667
1113	217	27.27	30.24	-2.967
1116	223	28.11	31.91	-3.801
1120	225	28.64	32.81	-4.167

Neutron Exposure 3.48 (11) nvt
Gamma Dose 1.56 (6) Rads

TABLE 4-25 VOLTAGE SENSING S/N 7 POST-TEST AT 160°F

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
0230	190	23.54	22.57	.967
0237	196	24.24	23.97	.267
0237	200	24.77	25.11	-.333
0238	204	25.37	26.24	-.867
0239	208	25.87	27.27	-1.400
0240	212	26.51	28.57	-2.067
0241	216	27.11	29.75	-2.634
0242	220	27.64	30.91	-3.267

Neutron Exposure 7.5 (11) nvt
Gamma Dose 2.13 (6) Rads

TABLE 4-26 VOLTAGE SENSING S/N 8 PRE-TEST AT 160°F

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
0154	196	24.20	23.64	.567
0157	212	26.57	28.34	-1.767
0201	220	27.74	30.67	-2.934

TABLE 4-27 - VOLTAGE SENSING S/N 8 AT END OF LOW POWER RUN

Time	Input Voltage Volts RMS	Output dc Volts Half Output V4	Half Output V5	Differential Output V6
1054	190	23.47	22.14	1.334
1058	195	24.30	23.70	.600
1101	200.	24.97	25.17	-.200
1105	204.	25.51	26.27	-.767
1109	208.	26.24	27.57	-1.334
1113	217.	27.44	30.11	-2.667
1116	223.	28.31	31.81	-3.501
1120	225.	28.77	32.71	-3.934

Neutron Exposure 3.48 (11) nvt
Gamma Dose 1.37 (6) Rads

TABLE 4-28 VOLTAGE SENSING S/N 8 POST TEST AT 160°F

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
0230	190.	23.64	22.27	1.367
0237	196.	24.37	23.77	.600
0237	200.	24.90	24.90	0.
0238	204.	25.47	26.14	-.667
0239	208.	25.97	27.07	-1.100
0240	212.	26.64	28.41	-1.767
0241	216.	27.21	29.54	-2.334
0242	220.	27.81	30.74	-2.934

Neutron Exposure 7.5 (11) nvt
Gamma Dose 1.87 (6) Rads

TABLE 4-29 VOLTAGE SENSING S/N 9 PRE-TEST AT 160°F

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
0154	196.0	24.07	23.34	.733
0157	212.0	26.44	28.14	-1.700
0201	220.0	27.51	30.47	-2.967

TABLE 4-30 VOLTAGE SENSING S/N 9 AT END OF LOW POWER RUN

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
1054	190	23.34	21.97	1.367
1058	195	24.14	23.50	.633
1101	200	24.87	24.97	-1.000
1105	204	25.37	26.07	-.700
1109	208	26.07	27.44	-1.367
1113	217	27.31	29.91	-2.601
1116	223	28.14	31.57	-3.434
1120	225	28.64	32.57	-3.934

Neutron Exposure 4.64 (11) nvt
Gamma Dose 2.78 (6) Rads

TABLE 4-31 VOLTAGE SENSING S/N 9 POST-TEST AT 160°F

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
0231	190	23.17	21.70	1.467
0237	196	24.17	23.67	.500
0238	200	24.74	24.74	0.
0238	204	25.31	25.97	-.667
0239	208	25.81	26.94	-1.134
0240	212	26.44	28.27	-1.834
0241	216	27.01	29.37	-2.367
0242	220	27.61	30.57	-2.967

Neutron Exposure 1.0 (12) nvt
Gamma Dose 3.8 (6) Rads

TABLE 4-32 VOLTAGE SENSING S/N 10 PRE-TEST AT 160°F

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
0154	196	24.27	24.07	.200
0157	212.	26.61	28.74	-2.134
0201	220.	27.67	30.97	-3.301

TABLE 4-33 VOLTAGE SENSING S/N 10 AT END OF LOW POWER RUN

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
1054	190	23.54	22.54	1.000
1058	195	24.34	24.14	.200
1101	200	24.97	25.57	-.600
1105	204	25.57	26.57	-1.000
1109	208	26.24	27.97	-1.734
1113	217	27.47	30.47	-3.001
1116	223	28.34	32.14	-3.801
1120	225	28.77	33.11	-4.334

Neutron Exposure 4.64 (11) nvt
Gamma Dose 2.78 (6) Rads

TABLE 4-34 VOLTAGE SENSING S/N 10 POST-TEST AT 160°F

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
0231	190	23.37	22.27	1.100
0237	196	24.34	24.27	.067
0238	200	24.94	25.31	-.367
0238	204	25.47	26.47	-1.000
0239	208	26.01	27.47	-1.467
0240	212	26.64	28.81	-2.167
0241	216	27.24	29.97	-2.734
0242	220	27.81	31.11	-3.301

Neutron Exposure 1.0 (12) nvt
Gamma Dose 3.95 (6) Rads

TABLE 4-35 CONTROL VOLTAGE SENSING S/N 11 PRE-TEST AT 160°F

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
0154	196	24.14	23.54	.600
0157	212	26.47	28.31	-1.834
0201	220	27.61	30.54	-2.934

TABLE 4-36 CONTROL VOLTAGE SENSING S/N 11 POST-TEST AT 160°F

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
0231	190	23.40	21.94	1.467
0237	196	24.40	23.90	.500
0238	200	24.94	25.00	-.067
0238	204	25.51	26.17	-.667
0239	208	26.01	27.17	-1.167
0240	212	26.64	28.51	-1.867
0241	216	27.24	29.67	-2.434
0242	220	27.81	30.81	-3.001

TABLE 4-37 CONTROL VOLTAGE SENSING S/N 12 PRE-TEST AT 160°F

Time	Input Voltage Volts RMS	Output dc Volts		
		Half Output V4	Half Output V5	Differential Output V6
0154	196	24.14	23.50	.633
0157	212	26.47	28.81	-1.834
0201	222	27.57	30.54	-2.967

TABLE 4-36 CONTROL VOLTAGE SENSING S/N 12 POST-TEST AT 160°F

Time	Input Voltage Volts RMS	Output dc Volts Half Output V4	Output dc Volts Half Output V5	Output dc Volts Differential Output V6
0237	196	24.40	23.94	.467
0238	200	24.94	25.00	-.067
0238	204	25.54	26.21	-.667
0239	208	26.01	27.17	-1.167
0240	212	26.64	28.57	-1.934
0241	216	27.27	29.71	-2.434
0242	220	27.81	30.87	-3.067

TABLE 4-39 TOTAL IRRADIATION DATA FOR VOLTAGE SENSING SUBASSEMBLIES

Serial Number	Neutron nvt $\times 10^{-3}$	Gamma Rads $\times 10^{-6}$
1	4.4	3.4
2	4.4	3.0
3	6.3	6.1
4	6.3	6.3
7	.075	2.13
8	.075	1.87
9	.10	3.8
10	.10	3.95

4.2 4 DIODE FREQUENCY SENSING

The output from the 4 Diode Frequency Sensing units shows a slight change at the end of the 160°F test run. The changes can be attributed to increased forward voltage drop of the 1N547 diodes. This particular circuit actually magnifies the effect due to radiation induced changes. The actual change in differential output is twice the change in the forward voltage drop. This effect can be seen in Figure 4-10. This oscillograph pictures shows the differential output vs. frequency. The frequency starts at 380 cps at the left, reached 425 cps at the center and is back to 380 cps at the right. The series resonance of both LC circuits may also serve as frequency references.

The data shows that the slope at null is not changed. There is, however, a shift in null frequency due to the difference in change of forward characteristics of individual diodes in the "ring".

Both tests showed similar changes at equivalent doses; therefore, the temperature difference of 60°F had no noticeable effect.

With the LiH shield removed for the last five hours of the 100°F test, the neutron dose caused gross changes in the diode characteristics. The output increased such that the limit of the recorder was exceeded at the extreme frequencies being monitored. Bench tests made after the irradiation confirmed that the general slope of the curve was unchanged. The data for these units are shown in Tables 4-40 thru 4-81. The differential output for a representative unit is shown in Figure 4-8 and 4-9.

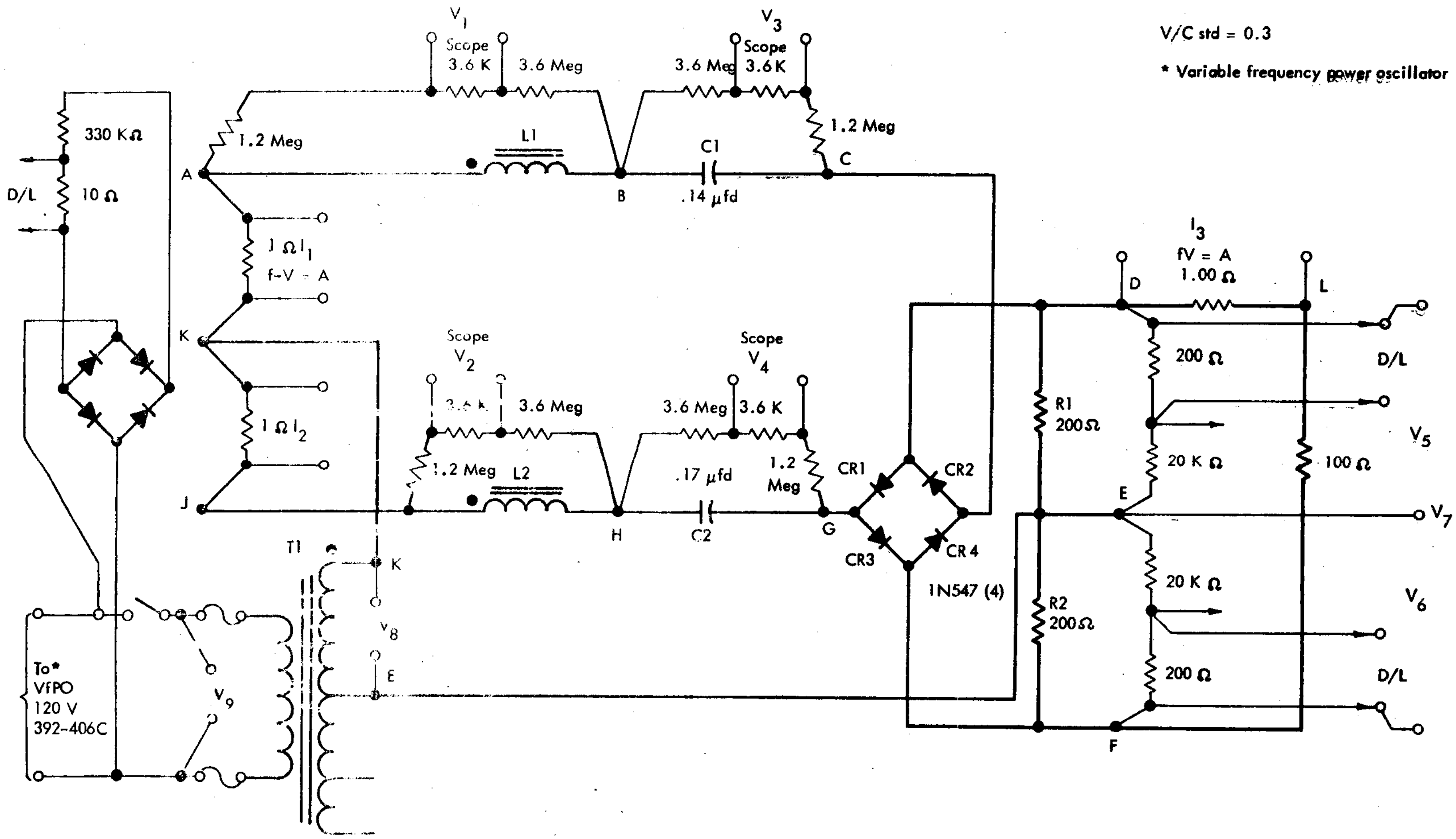


FIGURE 4 - 7 4 DIODE FREQUENCY SENSING UNIT (TYPICAL)

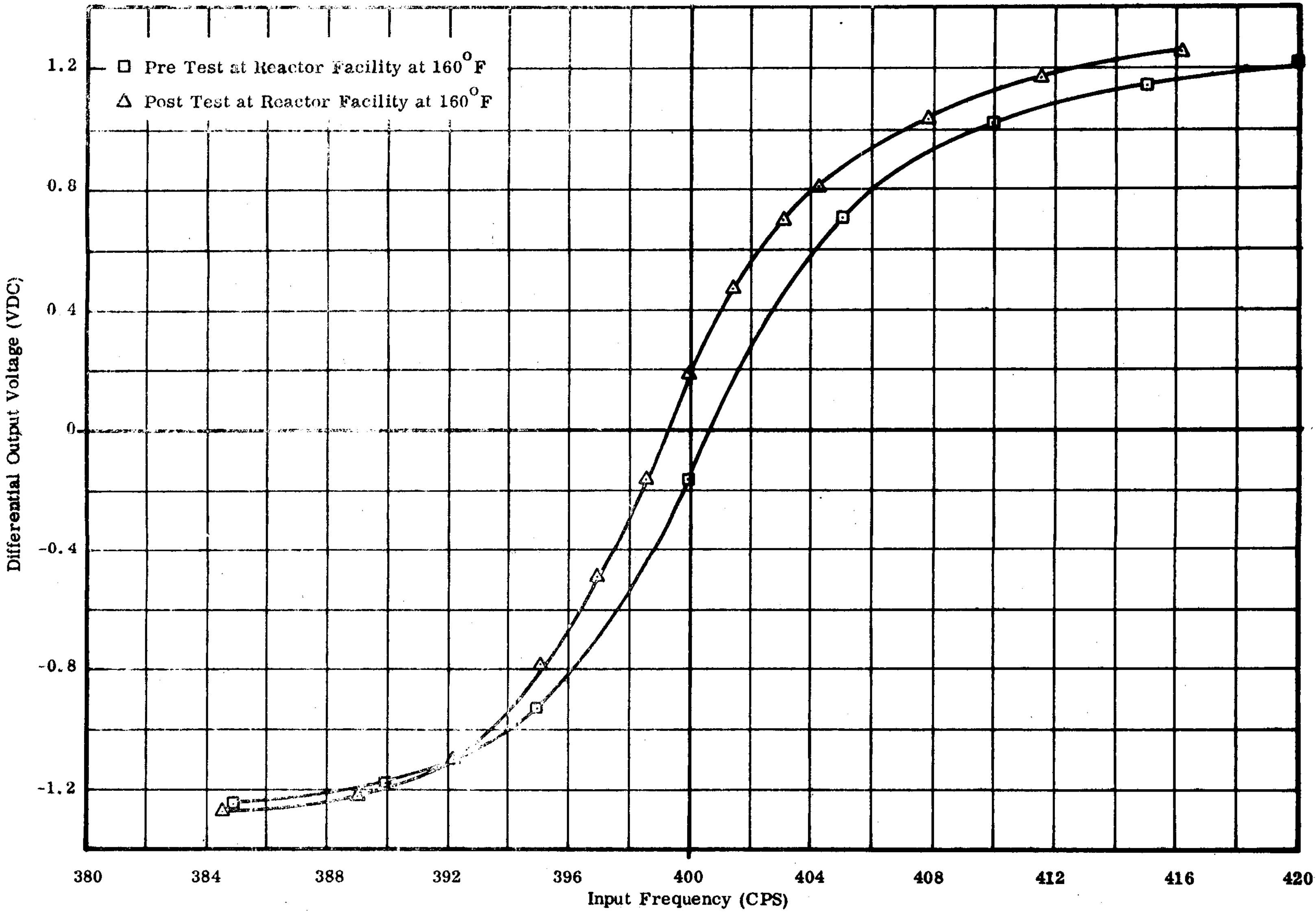


FIGURE 4-8 INPUT FREQUENCY VERSUS DIFFERENTIAL OUTPUT VOLTAGE, PRE AND POST TEST (4 DIODE FREQUENCY SENSOR, SN#7), 160° F

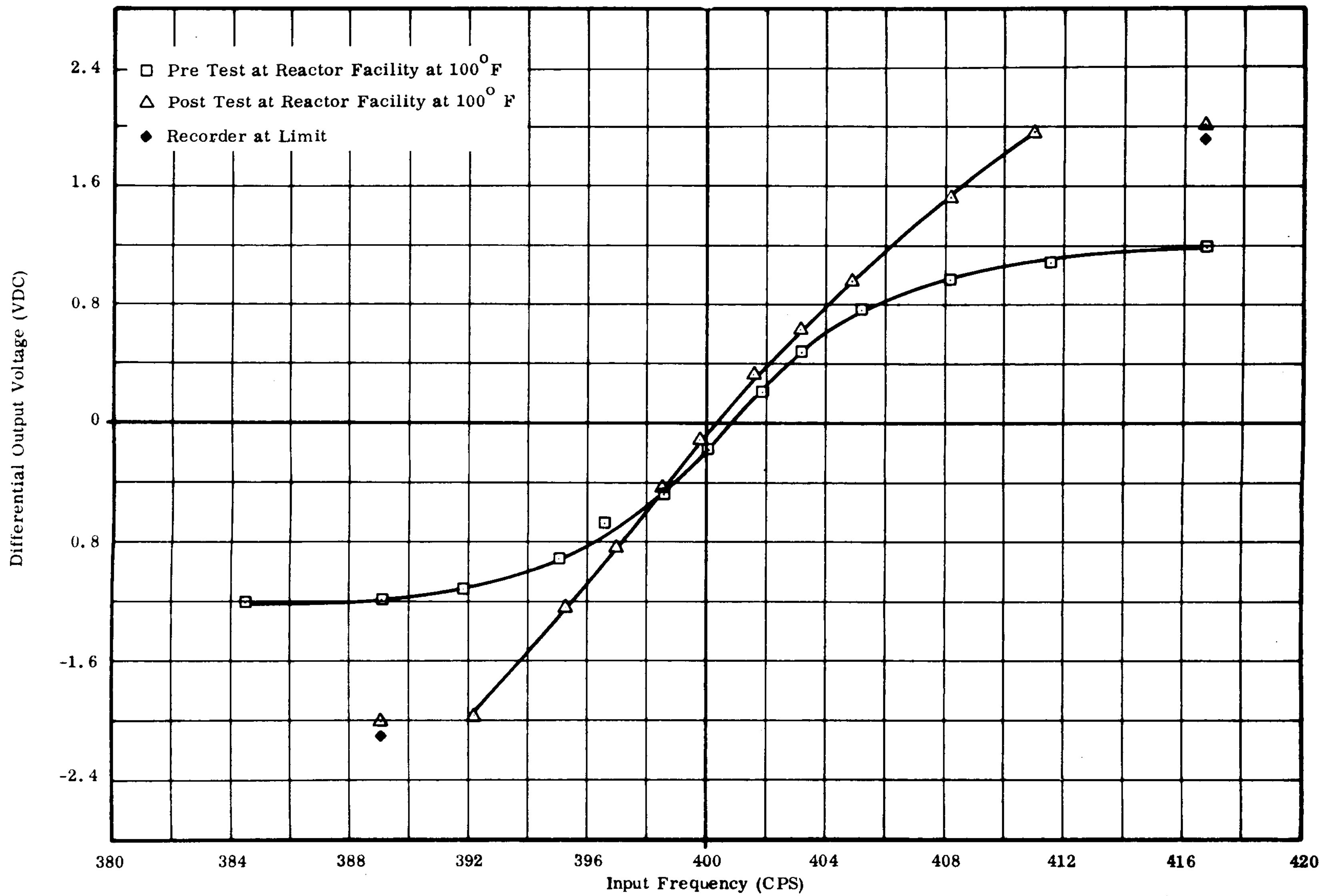
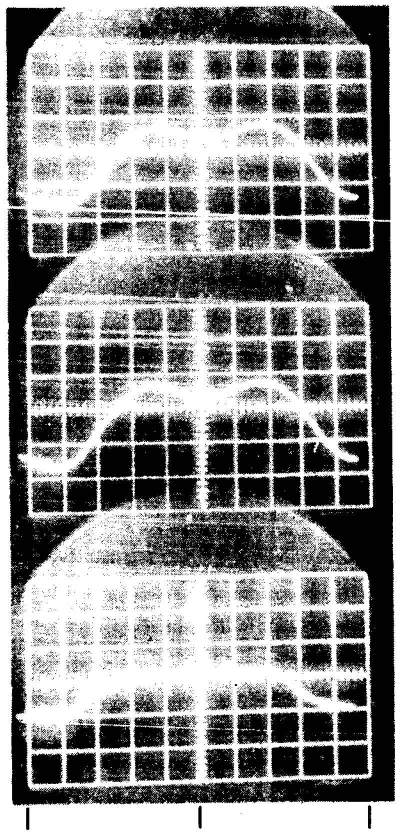


FIGURE 4-9 INPUT FREQUENCY VERSUS DIFFERENTIAL OUTPUT VOLTAGE, PRE AND POST TEST (4 DIODE FREQUENCY SENSOR, SN#A-1), 100° F

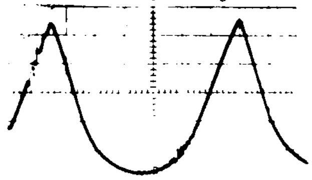
Date: 7/16/64
Time: 2240 Hours



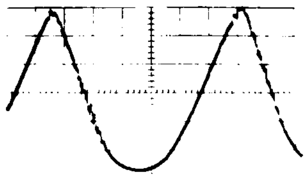
Sweep Speed: .5 sec/cm
Gain: 2 V/cm

FIGURE 4 - 10 4-DIODE FREQUENCY SENSING DIFFERENTIAL OUTPUT WITH SWEEP OSCILLATOR INPUT

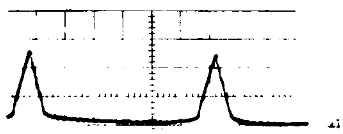
Date: 7/17/64
Time: 1031
Ambient Temperature
Input Frequency: 485. 3 cps



SN 1/V7

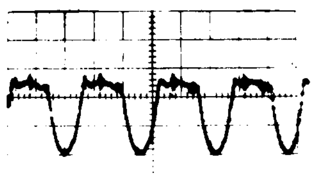


SN 2/V7

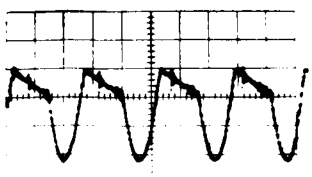


SN 6/V7

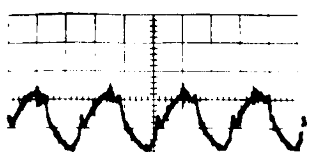
Sweep Speed: .2 m sec/cm
Gain: 100 MV/cm



SN 1/I3



SN 2/I3



SN 6/I3

Sweep Speed: 1 m sec/cm
Gain: 10 MV/cm

FIGURE 4 - 11 SELECTED WAVE SHAPES FROM 4 DIODE FREQUENCY SENSING UNITS , POST-TEST

TABLE 4-40 FUNCTIONAL PRE-TEST AT LABORATORY 4 DIODE FREQUENCY SENSOR

S/N	Null Frequency (CPS)	I_3 (MA) at Frequency (CPS)					
		410	417	422	387	392	397
A1	401.0	5.40	6.07	6.35	-6.24	-5.70	-3.30
A2	401.0	5.30	6.10	6.40	-6.40	-6.10	-4.55
A3	401.0	5.35	6.20	6.45	-6.40	-5.90	-4.30
A4	401.0	5.50	6.20	6.45	-6.40	-5.90	-4.30
A5	401.7	5.20	6.10	6.40	-6.45	-6.10	-4.20
A6	400.8	5.40	6.10	6.40	-6.40	-6.00	-4.00
A7	401.4	5.30	6.10	6.40	-6.45	-6.15	-4.30
A8	401.4	5.30	6.10	6.40	-6.45	-6.00	-4.25
A9	400.8	5.30	6.10	6.35	-6.40	-5.90	-3.75
A10	400.6	5.30	6.10	6.35	-6.35	-5.90	-4.00
A11	400.7	5.40	6.15	6.40	-6.45	-5.90	-3.80
A12	401.2	5.20	6.00	6.30	-6.45	-6.00	-4.10

TABLE 4-41 PRE AND POST DATA AT LABORATORY 4 DIODE FREQUENCY SENSORS

F1 (CPS)	401 *	410	417	422	387	392	397
Pre-Test Model 092381-1B S/N A1							
V1 (VAC)	185	275	331	366	37.5	90.0	154
V2 (VAC)	186	112	76.0	46.4	340	314	224
V3 (VAC)	204	291	346	374	44	103	172
V4 (VAC)	168	96	65	37	340	300	206
V5 (VDC)	0	0.541	0.607	0.633	-0.624	-0.568	-0.345
V6 (VDC)	0	0.541	0.607	0.633	-0.625	-0.568	-0.345
V7 (VDC)	0	1.075	1.207	1.260	-1.240	-1.134	-0.680
I_1 (MA)	74	106	126	148	15.3	35.6	60.5
I_2 (MA)	74	42.4	27.0	17.1	140	126	87.0
V8 (VAC)	21.2	21.2	21.0	20.8	20.6	20.8	21.2
I_3 (MA)	0	5.4	6.07	6.35	-6.24	-5.70	-3.30
Post-Test Model 092381-1B S/N A1							
V1 (VAC)	170	235	300	320	58	88	135
V2 (VAC)	168	110	63	43	290	264	209
V3 (VAC)	188	250	310	320	67	100	150
V4 (VAC)	150	95	52	34.5	285	251	193
V5 (VDC)	0.0025	0.838	1.168	1.260	-1.310	-1.100	-0.548
V6 (VDC)	-0.0025	-0.842	-1.170	-1.270	1.320	1.130	0.549
V7 (VDC)	-0.0014	1.685	2.330	2.540	-2.590	-2.200	-1.080
I_1 (MA)	65	88	110	118	18.5	33	51
I_2 (MA)	65	43	25.8	18	118	108	82
V8 (VAC)	20.88	20.8	20.5	20.3	20.3	20.5	20.7
I_3 (MA)	0	16.8	23.8	25.0	-26.0	21.5	-11.0
Post-Test Model 092381-1B S/N A1 with S/N A11 Diodes Substituted							
V1 (VAC)	185	260	330	361	39	78	139
V2 (VAC)	180	120	75	46	340	325	240
V3 (VAC)	202	275	340	370	46	88	156
V4 (VAC)	161	105	61	36	340	320	225
V5 (VDC)	0.002	0.497	0.591	0.617	-0.633	-0.593	-0.439
V6 (VDC)	-0.0024	-0.499	-0.597	-0.625	0.627	0.590	0.439
V7 (VDC)	0.002	0.993	1.194	1.244	-1.268	-1.198	-0.887
I_1 (MA)	70.1	99.0	123	135	13.8	29.5	54.0
I_2 (MA)	70.1	46.5	29.8	18.9	139	131	96.0
V8 (VAC)	20.8	20.8	20.5	20.5	20.1	20.2	20.6
I_3 (MA)	0	9.9	12.0	13.0	-12.8	-12.0	-8.6

* Null frequency on post-test measurements was 402 CPS.

TABLE 4-42 4 DIODE FREQUENCY SENSING S/N 1 PRE-TEST AT 100°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
2150	425.4	.6161	-.6151	1.2312
2155	416.7	.5838	-.5828	1.1666
2158	411.5	.5333	-.5333	1.0666
2202	408.2	.4727	-.4697	.9424
2205	404.9	.3535	-.3515	.7050
2209	387.4	.2412	-.2384	.4796
2213	401.6	.1111	-.1050	.2161
2216	399.8	-.0898	.0899	-.1798
2220	398.2	-.2475	.2424	-.4899
2222	396.8	-.3596	.3535	-.7131
2225	395.3	-.4434	.4373	-.8807
2227	392.2	-.5373	.5353	-1.0726
2229	389.3	-.5787	.5797	-1.1584
2231	384.5	-.5999	.6050	-1.2049

TABLE 4-43 4 DIODE FREQEUNCY SENSING S/N 1, 100°F AT END OF LOW POWER RUN

Time	Input Frequency CPS	Output dc Volts Half Output V5	Half Output V6	Differential Output V7
2313	425.4	.6141	-.6110	1.2251
2317	416.7	.5828	-.5808	1.1636
2320	411.7	.5343	-.5303	1.0646
2325	408.2	.4737	-.4666	.9403
2329	405.0	.3666	-.3606	.7272
2334	403.4	.2808	-.2767	.5575
2337	401.6	.1363	-.1323	.2686
2341	399.8	-.0394	.0434	-.0828
2344	398.6	-.1767	.1737	-.3504
2346	396.8	-.3262	.3232	-.6494
2348	395.1	-.4192	.4161	-.8353
2350	392.2	-.5252	.5272	-1.0524
2352	389.1	-.5737	.5787	-1.1524
2355	384.6	-.5949	.5999	-1.1948

Neutron Exposure 5.13 (11) nvt
Gamma Dose 1.44 (6) Rads

TABLE 4-44 4 DIODE FREQUENCY SENSING S/N 1, 100°F AT END OF TEST WITH LiH SHIELD

Time	Input Frequency CPS	Output dc Volts Half Output V5	Half Output V6	Differential Output V7
1614	425.5	.6666	-.6605	1.3271
1617	416.8	.6333	-.6292	1.2625
1621	411.5	.5747	-.5676	1.1323
1625	408.0	.5020	-.4929	.9949
1628	404.7	.3747	-.3676	.7413
1631	403.1	.2737	-.2676	.5413
1635	401.8	.1535	-.1454	.2989
1639	399.8	-.0677	.0757	-.1434
1642	398.4	-.2111	.2081	-.4192
1645	396.8	-.3525	.3484	-.7009
1647	395.3	-.4515	.4474	-.8989
1656	392.3	-.5605	.5767	-1.1372
1659	389.0	-.6312	.6403	-1.2715
1701	384.6	-.6545	.6636	-1.3181

Neutron Exposure 1.2 (12) nvt
Gamma Dose 3.4 (6) Rads

TABLE 4-45 4 DIODE FREQUENCY SENSING S/N 1 POST-TEST AT 100°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
0926	425.5	>1.009	<-1.009	>2.0180
0930	416.7	>1.009	<-1.009	>2.0180
0934	411.5	.9989	-.9666	1.9655
0940	408.2	.7767	-.7191	1.4958
0946	404.9	.4919	-.4232	.9151
0951	403.2	.3484	-.3353	.6837
0955	401.6	.1778	-.1697	.3475
0959	400.0	-.1515	.1919	-.3434
1003	398.4	-.2010	.1959	-.3969
1019	396.8	-.3889	.3838	-.7727
1022	395.3	-.5828	.5706	-1.1534
1027	392.2	-.9393	.9433	-1.8826
1031	389.1	<-1.009	> 1.009	<-2.0180
1035	384.6	<-1.009	> 1.009	<-2.0180

Neutron Exposure 4.7 (13) nvt
Gamma Dose 5.4 (6) Rads

TABLE 4-46 4 DIODE FREQUENCY SENSING S/N 2 PRE-TEST AT 100°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
2150	425.4	.6131	-.6131	1.2262
2155	416.7	.5818	-.5797	1.1615
2158	411.5	.5333	-.5313	1.0646
2202	408.2	.4777	-.4717	.9494
2205	404.9	.3626	-.3586	.7212
2209	403.1	.2586	-.2545	.5131
2213	401.6	.1333	-.1293	.2626
2216	399.8	-.0616	.0616	-.1232
2220	398.2	-.2232	.2192	-.4424
2222	396.8	-.3434	.3353	-.6787
2225	395.3	-.4323	.4262	-.8585
2227	392.2	-.5323	.5303	-1.0624
2229	389.3	-.5828	.5818	-1.1646
2231	384.5	-.6090	.6121	-1.2211

TABLE 4-47 4 DIODE FREQUENCY SENSING S/N 2 AT END OF LOW POWER RUN

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
2313	425.4	.6242	-.6211	1.2453
2317	416.7	.5939	-.5908	1.1847
2320	411.7	.5434	-.5414	1.0848
2325	408.2	.4828	-.4767	.9595
2329	405.0	.3798	-.3747	.7545
2334	403.4	.2990	-.2939	.5929
2337	401.6	.1596	-.1555	.3151
2341	399.8	-.0081	.0182	.0263
2344	398.6	-.1525	.1515	-.3040
2346	396.8	-.3141	.3101	-.6242
2348	395.1	-.4171	.4131	-.8302
2350	392.2	-.5363	.5373	-1.0736
2352	389.1	-.5969	.5999	-1.1968
2355	384.6	-.6232	.6272	-1.2504

Neutron Exposure 7.26 (11) nvt
Gamma Dose 1.77 (6) Rads

TABLE 4-48 4 DIODE FREQUENCY SENSING S/N 2, 100°F, AT END OF TEST WITH LiH SHIELD

Time	Input	Output dc Volts		
	Frequency CPS	Half Output V5	Half Output V6	Differential Output V7
1614	425.5	.7040	-.6959	1.3999
1617	416.8	.6706	-.6650	1.3356
1621	411.5	.6080	-.5989	1.2069
1625	408.0	.5292	-.5212	1.0504
1628	404.7	.4020	-.3939	.7959
1631	403.1	.3020	-.2939	.5959
1635	401.8	.1818	-.1737	.3555
1639	399.8	-.0367	.0414	-.0778
1642	398.4	-.1848	.1838	-.3686
1645	396.8	-.3434	.3383	-.6817
1647	395.3	-.4565	.4525	-.9090
1656	392.3	-.5898	.6040	-1.1938
1659	389.0	-.6797	.6878	-1.3675
1701	384.6	-.7110	.7191	-1.4301

Neutron Exposure 1.7 (12) nvt
Gamma Dose 4.2 (6) Rads

TABLE 4-49 4 DIODE FREQUENCY SENSING S/N 2, POST-TEST AT 100°F

Time	Input	Output dc Volts		
	Frequency CPS	Half Output V5	Half Output V6	Differential Output V7
0926	425.5	>1.009	<-1.009	>2.0180
0930	416.7	>1.009	<-1.009	>2.0180
0934	411.5	.9413	-.9342	1.8755
0940	408.2	.7262	-.7080	1.4342
0946	404.9	.4606	-.4434	.9040
0951	403.2	.3313	-.3151	.6464
0955	401.6	.1778	-.1697	.3475
0959	400.0	.2222	-.0152	.2374
1003	398.4	-.1616	.1576	-.3192
1019	396.8	-.3303	.3232	-.6535
1022	395.3	-.5050	.4919	-.9969
1027	392.2	-.8585	.8565	-1.7150
1031	389.1	<-1.009	> 1.009	<-2.0180
1035	384.6	<-1.009	> 1.009	<-2.0180

Neutron Exposure 6.4 (13) nvt
Gamma Dose 6.7 (6) Rads

TABLE 4-50 4 DIODE FREQUENCY SENSING S/N 3 PRE-TEST AT 100°F

Time	Input Frequency CPS	Output dc Volts Half Output V5	Half Output V6	Differential Output V7
2151	425.4	.6211	-.6201	1.2412
2155	416.7	.5878	-.5868	1.1746
2158	411.5	.5353	-.5353	1.0706
2202	408.2	.4747	-.4727	.9474
2206	404.9	.3545	-.3525	.7070
2209	387.4	.2424	-.2394	.4818
2213	401.6	.1121	-.1071	.2192
2217	399.8	-.0859	.0848	-.1707
2221	398.2	-.2404	.2363	-.4767
2223	396.8	-.3545	.3474	-.7019
2225	395.3	-.4383	.4323	.8706
2227	392.2	-.5323	.5313	1.0636
2229	389.3	-.5787	.5787	1.1574
2231	384.5	-.6009	.6060	1.2069

TABLE 4-51 4 DIODE FREQUENCY SENSING S/N 3 AT END OF LOW POWER RUN

Time	Input Frequency CPS	Output dc Volts Half Output V5	Half Output V6	Differential Output V7
2313	425.4	.6161	-.6141	1.2302
2317	416.4	.5828	-.5808	1.1636
2321	411.7	.5333	-.5292	1.0625
2325	408.2	.4707	-.4636	.9343
2329	405.0	.3616	-.3555	.7171
2334	403.4	.2747	-.2707	.5454
2337	401.6	.1313	-.1273	.2586
2341	399.8	-.0434	.0455	-.0889
2344	398.6	-.1838	.1818	-.3656
2346	396.8	-.3404	.3363	-.6767
2349	395.1	-.4363	.4333	-.8696
2351	392.2	-.5525	.5545	-1.1070
2353	389.1	-.6090	.6131	-1.2221
2355	384.6	-.6312	.6383	-1.2695

Neutron Exposure 8.12 (11) nvt
Gamma Dose 1.57 (6) Rads

TABLE 4-52 4 DIODE FREQUENCY SENSING S/N 3 AT END OF TEST WITH LiH SHIELD

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
1614	425.6	.6898	-.6838	1.3736
1618	416.8	.6525	-.6484	1.3009
1622	411.5	.5898	-.5828	1.1726
1625	408.0	.5100	-.5020	1.0120
1628	404.7	.3787	-.3717	.7504
1632	403.1	.2747	-.2666	.5413
1636	401.8	.1515	-.1444	.2959
1639	399.8	-.0717	.0778	-.1495
1643	398.4	-.2192	.2192	-.4384
1645	396.8	-.3767	.3727	-.7494
1648	395.3	-.4909	.4858	-.9767
1657	392.3	-.6252	.6393	-1.2645
1659	389.0	-.7110	.7181	-1.4291
1702	384.6	-.7403	.7484	-1.4887

Neutron Exposure 1.9 (12) nvt
Gamma Dose 3.7 (6) Rads

TABLE 4-53 4 DIODE FREQUENCY SENSING S/N 3 POST-TEST AT 100°F

Time	Input	Output dc Volts		
	Frequency CPS	Half Output V5	Half Output V6	Differential Output V7
0926	425.5	>1.009	<-1.009	>2.0180
0930	416.7	>1.009	<-1.009	>2.0180
0935	411.5	.9837	-.9827	1.9664
0940	408.2	.7686	-.7595	1.5281
0947	404.9	.4858	-.4727	.9585
0952	403.2	.3444	- .3333	.6777
0956	401.6	.1767	-.1707	.3474
1000	400.0	-.0131	.0182	-.0313
1003	398.4	-.1969	.1899	-.3868
1019	396.8	-.3838	.3757	-.7595
1022	395.3	-.5696	.5595	-1.1291
1028	392.2	-.9231	.9241	-1.8472
1031	389.1	<-1.009	>1.009	<-2.0180
1035	384.6	<-1.009	>1.009	<-2.0180

Neutron Exposure 5.5 (13) nvt
Gamma Dose 5.9 (6) Rads

TABLE 4-54 4 DIODE FREQUENCY SENSING S/N 4 PRE-TEST AT 100°F

Time	Input Frequency CPS	Output dc Volts Half Output V5	Half Output V6	Differential Output V7
2151	425.4	.6161	-.6171	1.2332
2155	416.7	.5848	-.5858	1.1706
2158	411.5	.5363	-.5383	1.0746
2202	408.2	.4787	-.4797	.9584
2206	404.9	.3717	-.3697	.7414
2209	387.4	.2697	-.2666	.5363
2213	401.6	.1454	-.1424	.2878
2217	399.8	-.0515	.0515	-.1030
2221	398.2	-.2182	.2141	-.4323
2223	396.8	-.3424	.3353	-.6777
2225	395.3	-.4313	.4262	-.8575
2227	392.2	-.5343	.5333	-1.0676
2229	389.3	-.5797	.5828	-1.1625
2231	384.5	-.6030	.6070	-1.2100

TABLE 4-55 4 DIODE FREQUENCY SENSING S/N 4 AT END OF LOW POWER RUN

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
2313	425.4	.6939	-.6929	1.3868
2317	416.7	.6585	-.6575	1.3160
2321	411.7	.6030	-.5999	1.2029
2325	408.2	.5343	-.5292	1.0365
2329	405.0	.4202	-.4161	.8363
2334	403.4	.3323	-.3282	.6605
2337	401.6	.1828	-.1788	.3616
2341	399.8	.0212	-.0121	.0333
2344	398.6	-.1485	.1475	-.2960
2346	396.8	-.3282	.3252	-.6534
2349	395.1	-.4424	.4404	-.8828
2351	392.2	-.5828	.5838	-1.1666
2353	389.1	-.6464	.6504	-1.2968
2355	384.6	-.6706	.6777	-1.3483

Neutron Exposure 1.07 (11) nvt
Gamma Dose 1.23 (6) Rads

TABLE 4-56 4 DIODE FREQUENCY SENSING S/N 4 AT END OF TEST WITH LiH SHIELD

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
1614	425.5	.8696	-.8666	1.7362
1618	416.8	.8262	-.8252	1.6514
1622	411.5	.7413	-.7363	1.4776
1625	408.0	.6373	-.6302	1.2675
1628	404.7	.4717	-.4616	.9333
1632	403.1	.3495	-.3373	.6868
1636	401.8	.2131	-.2020	.4151
1639	399.8	-.0141	.0242	-.0383
1643	398.4	-.1747	.1778	-.3525
1645	396.8	-.3606	.3596	-.7202
1648	395.3	-.5070	.5050	-1.0120
1657	392.3	-.7040	.7161	-1.1201
1659	389.0	-.8171	.8282	-1.6453
1702	384.6	-.8555	.8656	-1.7211

Neutron Exposure 2.5 (12) nvt
Gamma Dose 2.9 (6) Rads

TABLE 4-57 4 DIODE FREQUENCY SENSING S/N 4 POST-TEST AT 100°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
0926	425.5	> 1.009	<-1.009	>2.0180
0930	416.7	> 1.009	<-1.009	>2.0180
0935	411.5	>1.009	<-1.009	>2.0180
0940	408.2	.7858	-.7767	1.5625
0947	404.9	.5050	-.4929	.9979
0952	403.2	.3757	-.3636	.7393
0956	401.6	.2272	-.2171	.4443
1000	400.0	.0768	-.0253	.1021
1003	398.4	-.9494	.9393	-1.8887
1019	396.8	-.2515	.2464	-.4979
1022	395.3	-.4080	.3959	-.8039
1028	392.2	-.7181	.7110	-1.4291
1031	389.1	<-1.009	>1.009	<-2.0180
1035	384.6	<-1.009	> 1.009	<-2.0180

Neutron Exposure 8.4 (13) nvt
Gamma Dose 4.65 (6) Rads

TABLE 4-58 4 DIODE CONTROL FREQUENCY SENSING S/N 5 PRE-TEST AT 100°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
2151	425.4	.6161	-.6090	1.2251
2155	416.7	.5797	-.5727	1.1524
2159	411.5	.5282	-.5191	1.0473
2202	408.2	.4595	-.4525	.9120
2206	404.9	.3282	-.3212	.6494
2209	387.4	.2050	-.1990	.4040
2213	401.6	.0646	-.0576	.1222
2217	399.8	-.1353	.1323	-.2676
2221	398.2	-.2838	.2757	-.5595
2223	396.8	-.3878	.3767	-.7645
2225	395.3	-.4626	.4535	-.9161
2228	392.2	-.5515	.5444	-1.0959
2230	389.3	-.5939	.5898	-1.1837
2232	384.5	-.6100	.6080	-1.2180

TABLE 4-59 4 DIODE FREQUENCY SENSING S/N 5 POST-TEST AT 100°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
0926	425.5	.6246	-.6171	1.2413
0931	416.7	.5888	-.5808	1.1696
0935	411.5	.5353	-.5292	1.0645
0940	408.2	.4707	-.4626	.9333
0947	404.9	.3444	-.3353	.6797
0952	403.2	.2464	-.2384	.4848
0956	401.6	.0990	-.0939	.1929
1000	400.0	-.0949	.0949	-.1898
1004	398.4	-.2555	.2475	-.5030
1020	396.8	-.3707	.3636	-.7343
1023	395.3	-.4535	.4444	-.8979
1028	392.2	-.5504	.5434	-1.0938
1032	389.1	-.5989	.5949	-1.1938
1035	384.6	-.6151	.6131	-1.2282

TABLE 4-60 4 DIODE CONTROL FREQUENCY SENSING S/N 6 PRE-TEST AT 100°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
2151	425.4	.6121	-.6110	1.2231
2155	416.7	.5818	-.5808	1.1626
2159	411.5	.5353	-.5333	1.0686
2202	408.2	.4808	-.4767	.9575
2206	404.9	.3727	-.3697	.7424
2209	387.4	.2737	-.2697	.5424
2213	401.6	.1525	-.1495	.3020
2217	399.8	-.0424	.0455	-.0879
2221	398.2	-.2131	.2081	-.4212
2223	396.8	-.3404	.3333	-.6737
2225	395.3	-.4333	.4262	-.8595
2228	392.2	-.5393	.5353	-1.0746
2230	389.3	-.5868	.5868	-1.1736
2232	384.5	-.6070	.6090	-1.2160

TABLE 4-61 CONTROL 4 DIODE FREQUENCY SENSING S/N 6 POST-TEST AT 100°F

Time	Input Frequency CPS	Output ac volts		
		Half Output V5	Half Output V6	Differential Output V7
0926	425.5	.6181	-.6181	1.2362
0931	416.7	.5898	-.5878	1.1776
0935	411.5	.5454	-.5403	1.0857
0940	408.2	.4888	-.4848	.9736
0947	404.9	.3848	-.3798	.7646
0952	403.2	.3050	-.3000	.6050
0956	401.6	.1798	-.1747	.3545
1000	400.0	.1041	-.0505	.0646
1004	398.4	-.1818	.1767	-.3585
1020	396.8	-.3232	.3171	-.6403
1023	395.3	-.4222	.4141	-.8363
1028	392.2	-.5383	.5333	-1.0716
1032	389.1	-.5898	.5908	-1.1806
1035	384.6	-.6090	.6121	-1.2211

TABLE 4-62 4 DIODE FREQUENCY SENSING S/N 7 PRE-TEST AT 160°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
1458	392.0	-.5030	.5040	-1.0070
1500	397.9	-.2575	.2575	-.5140
1501	406.0	.3929	-.3858	.7787
1907	394.9	-.4222	-.4171	-.8393
1910	400.0	-.2020	.0252	-.4545
1912	401.9	.2212	-.2151	.4363
1914	405.0	.3767	-.3697	.7464
1916	410.0	.4929	-.4868	.9797

TABLE 4-63 4 DIODE FREQUENCY SENSING S/N 7 AT END OF LOW POWER RUN

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
1052	425.5	.5999	-.5999	1.1998
1056	416.5	.5747	-.5737	1.1484
1059	411.5	.5333	-.5303	1.0636
1103	404.7	.3959	-.3909	.7868
1107	400.8	.1606	-.1555	.3161
1111	395.9	-.3222	.3181	-.6403
115	392.2	-.5100	.5070	-1.0170
1118	386.1	-.5797	.5818	-1.1615

Neutron Exposure 5.56 (11) nvt
Gamma Dose 1.55 (6) Rads

TABLE 4-64 4 DIODE FREQUENCY SENSING S/N 7 POST-TEST AT 160°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
0043	416.1	.6343	-.6282	1.2625
0046	411.5	.5898	-.5818	1.1716
0048	407.8	.5222	-.5151	1.0373
0049	404.2	.4111	-.4010	.8121
0051	403.1	.3565	-.3454	.7019
0055	401.4	.2404	-.2303	.4707
0103	400.0	.1060	-.0929	.1989
0104	398.6	-.0747	.0828	-.1575
0105	397.0	-.2454	.2454	-.4908
0107	395.1	-.3909	.3899	-.7808
0109	392.2	-.5474	.5484	-1.0958
0110	389.1	-.6121	.6151	-1.2272
0112	384.6	-.6333	.6393	-1.2726

Neutron Exposure 1.2 (12) nvt
Gamma Dose 3.4 (6) Rads

TABLE 4-65 4 DIODE FREQUENCY SENSING S/N 8 PRE-TEST AT 160°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
1458	392.0	-.4868	.4898	-.9766
1500	397.9	-.2565	.2565	-.5130
1501	406.0	.3858	-.3828	.7686
1907	394.9	-.4090	.4070	-.8160
1910	400.0	-.0323	.0354	-.0677
1912	401.9	.2070	-.2030	.4100
1914	405.0	.3666	-.3656	.7322
1916	410.0	.4888	-.4878	.9766

TABLE 4-66 4 DIODE FREQUENCY SENSING S/N 8 AT END OF LOW POWER RUN

Time	Input Frequency CPS	Output ac Volts Half Output V5	Half Output V6	Differential Output V7
1052	425.5	.6030	-.6080	1.2110
1056	416.5	.5747	-.5777	1.1524
1059	411.5	.5292	-.5313	1.0605
1103	404.7	.3848	-.3848	.7696
1107	400.8	.1444	-.1404	.2848
1111	395.9	-.3232	.3202	-.6434
1115	392.2	-.5040	.5040	-1.0080
1118	386.1	-.5919	.5989	-1.1908

Neutron Exposure 7.88 (11) nvt
Gamma Dose 1.90 (6) Rads

TABLE 4-67 4 DIODE FREQUENCY SENSING S/N 8 POST-TEST AT 160°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
0043	416.1	.6383	-.6393	1.2776
0046	411.5	.5898	-.5898	1.1796
0048	407.8	.5191	-.5161	1.0352
0049	404.2	.4010	-.3939	.7949
0051	403.1	.3434	-.3363	.6797
0055	401.4	.2242	-.2171	.4413
0103	400.0	.0899	-.0808	.1707
0104	398.6	-.0919	.0960	-.1879
0105	397.0	-.2575	.2575	-.5150
0107	395.1	-.4030	.4030	-.8060
0109	392.2	-.5595	.5616	-1.1211
0110	389.1	-.6403	.6454	-1.2857
0112	384.6	-.6747	.6848	-1.3595

Neutron Exposure 1.7 (12) nvt
Gamma Dose 4.16 (6) Rads

TABLE 4-68 4 DIODE FREQUENCY SENSING S/N 9 PRE-TEST AT 160°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
1458	392.0	-.4747	.4737	-.9484
1500	397.9	-.2081	.2070	-.4151
1502	406.0	.4030	-.3969	.7999
1908	394.9	-.3818	.3787	-.7605
1910	400.0	.0475	-.0414	.0889
1912	401.9	.2505	-.2444	.4949
1914	405.0	.3848	-.3808	.7656
1917	410.0	.4989	-.4868	.9766

TABLE 4-69 4 DIODE FREQUENCY SENSING S/N 9 AT END OF LOW POWER RUN

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
1053	425.5	.6201	-.6191	1.2392
1056	416.5	.5929	-.5929	1.1858
1100	411.5	.5494	-.5474	1.0968
1103	404.7	.4141	-.4121	.8262
1108	400.8	.1959	-.1919	.3878
1111	395.9	-.2848	.2808	-.5656
1115	392.2	-.4939	.4898	-.9837
1119	386.1	-.5949	.5969	-1.1918

Neutron Exposure 8.81 (11) nvt
Gamma Dose 1.96 (6) Rads

TABLE 4-70 4 DIODE FREQUENCY SENSING S/N 9 POST-TEST AT 160°F

Time	Input	Output dc Volts		
	Frequency CPS	Half Output V5	Half Output V6	Differential Output V7
0044	416.1	.6888	-.6848	1.3736
0046	411.5	.6393	-.6333	1.2726
0048	407.8	.5666	-.5605	1.1271
0050	404.2	.4494	-.4424	.8918
0051	403.1	.3939	-.3858	.7797
0055	401.4	.2808	-.2717	.5525
0103	400.0	.1505	-.1424	.2929
0104	398.6	-.0253	.0323	-.0576
0106	397.0	-.2010	.2010	-.4020
0107	395.1	-.3676	.3646	-.7322
0109	392.2	-.5515	.5494	-1.0009
0111	389.1	-.6525	.6555	-1.3080
0112	384.6	-.6898	.6949	-1.3847

Neutron Exposure 1.9 (12) nvt
Gamma Dose 3.7 (6) Rads

TABLE 4-71 4 DIODE FREQUENCY SENSING S/N 10 PRE-TEST AT 160°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
1458	392.0	-.4686	.4666	-.9352
1500	397.9	-.1909	.1889	-.3798
1502	406.0	.4060	-.4030	.8090
1908	394.9	-.3727	.3676	-.7403
1910	400.0	.6565	-.0616	.7181
1912	401.9	.2606	-.2575	.5181
1914	405.0	.3909	-.3889	.7798
1917	410.0	.4919	-.4898	.9817

TABLE 4-72 4 DIODE FREQUENCY SENSING S/N 10 AT END OF LOW POWER RUN

Time	Input Frequency CPS	Output in Volts Half Output V5	Half Output V6	Differential Output V7
1053	425.5	.6646	-.6656	1.3302
1056	416.5	.6373	-.6383	1.2756
1100	411.5	.5888	-.5888	1.1776
1103	404.7	.4454	-.4434	.8888
1108	400.8	.2171	-.2131	.4302
1111	395.9	-.2828	.2767	-.5595
1115	392.2	-.5121	.5070	-1.0191
1119	386.1	-.6343	.6353	-1.2696

Neutron Exposure 1.16 (12) nvt
Gamma Dose 1.32 (6) Rads

TABLE 4-73 4 DIODE FREQUENCY SENSING S/N 10 POST-TEST AT 160°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
0044	416.1	.8019	-.8009	1.6028
0046	411.5	.7383	-.7363	1.4746
0048	407.8	.6484	-.6444	1.2928
0050	404.2	.5080	-.5020	1.0100
0051	403.1	.4434	-.4353	.8787
0055	401.4	.3151	-.3060	.6211
0103	400.0	.1778	-.1677	.2455
0104	398.6	.0101	.0111	.0212
0106	397.0	-.1899	.1909	-.3808
0107	395.1	-.3777	.3737	-.7514
0109	392.2	-.6040	.6020	-1.2060
0111	389.1	-.7383	.7413	-1.4796
0112	384.6	-.7959	.8009	-1.5968

Neutron Exposure 2.5 (12) nvt
Gamma Dose 2.9 (6) Rads

TABLE 4-74 CONTROL 4 DIODE FREQUENCY SENSING S/N 11 PRE-TEST AT 160°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
1459	392.0	-.5383	.5373	-1.0756
1500	397.9	-.2919	.2899	-.5818
1502	406.0	.4181	-.4090	.8271
1908	394.9	-.4656	.4616	-.9272
1911	400.0	-.0677	.0697	-.1374
1913	401.9	.2040	-.1969	.4009
1914	405.0	.3909	-.3828	.7737
1917	410.0	.5292	-.5232	1.0524

TABLE 4-75 CONTROL 4 DIODE FREQUENCY SENSING S/N 11 POST-TEST AT 160°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
0045	416.1	.5504	-.5434	1.0938
0047	411.5	.5181	-.5111	1.0292
0048	407.8	.4697	-.4616	.9313
0050	404.2	.3858	-.3757	.7615
0052	403.1	.3434	-.3343	.6777
0056	401.4	.2495	-.2414	.4909
0103	400.0	.1343	-.1262	.2605
0105	398.6	-.0323	.0384	-.0707
0106	397.0	-.1969	.1969	-.3938
0108	395.1	-.3373	.3343	-.6716
0109	392.2	-.4757	.4737	-.9494
0111	389.1	-.5414	.5444	-1.0858
0112	384.6	-.5676	.5717	-1.1393

TABLE 4-76 CONTROL 4 DIODE FREQUENCY SENSING S/N 12 PRE-TEST AT 160°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
1459	392.0	-.5474	.5454	-1.0928
1500	397.9	-.3272	.3202	-.6474
1502	406.0	.3889	-.3838	.7727
1908	394.9	-.4797	.4737	-.9534
1911	400.0	-.1192	.1172	-.2364
1913	401.9	.1555	-.1505	.3060
1914	405.0	.3596	-.3545	.7141
1917	410.0	.5121	-.5080	1.0201

TABLE 4-77 CONTROL 4 DIODE FREQUENCY SENSING S/N 12 POST-TEST AT 160°F

Time	Input	Output dc Volts		
	Frequency CPS	Half Output V5	Half Output V6	Differential Output V7
0045	416.1	.5393	-.5353	1.0746
0047	411.5	.5050	-.4989	1.0039
0048	407.8	.4515	-.4464	.8979
0050	404.2	.3565	-.3515	.7080
0052	403.1	.3091	-.3030	.6121
0056	401.4	. 2060	-.2000	.4060
0103	400.0	.0828	-.0758	.1586
0105	398.6	-.0909	.0919	-.1828
0106	397.0	-.2414	.2384	-.4798
0108	395.1	-.3646	.3606	-.7252
0109	392.2	-.4878	.4848	-.9726
0111	389.1	-.5494	.5494	-1.0988
0112	384.6	-.5757	.5787	-1.1544

TABLE 4-78 TOTAL IRRADIATION DATA FOR 4 DIODE FREQUENCY SENSING SUBASSEMBLIES

Serial Number	Neutron nvt $\times 10^{-13}$	Gamma Rads $\times 10^{-6}$
1	4.7	5.4
2	6.4	6.74
3	5.5	5.9
4	8.4	4.65
7	.12	3.4
8	.17	4.16
9	.19	3.7
10	.25	2.9

4.3 8 DIODE FREQUENCY SENSING

The change in the 8 Diode Frequency Sensing Circuits was not appreciable at the end of the 160°F test and at an equivalent dose on the 100°F test. The circuit configuration makes the output less dependent on the diode forward characteristics. Figure 4-13 shows that a null shift of approximately 1 cps occurred on 8D #1 at the conclusion of the 100°F test.

Figure 4-14 shows the bench data on the forward voltage drop of the diodes removed from 8D #1 after the test. The relatively lower voltage drops of the diodes from one bridge, dashed curves on figure, will account for the null shift.

The data Tables 4-82 thru 4-117 show that the voltage from each half did show a minor change due to radiation. The post bench data Table 4-84 shows that normal operation was restored when unirradiated diodes from 8D-12 were installed. The new null compares well with the pre-test null of 8D-12. The oscillograph picture in Figure 4-15 shows the output ripple voltage near null. A peak to peak difference of approximately one half volt may be noted. The direct current change is generally lower.

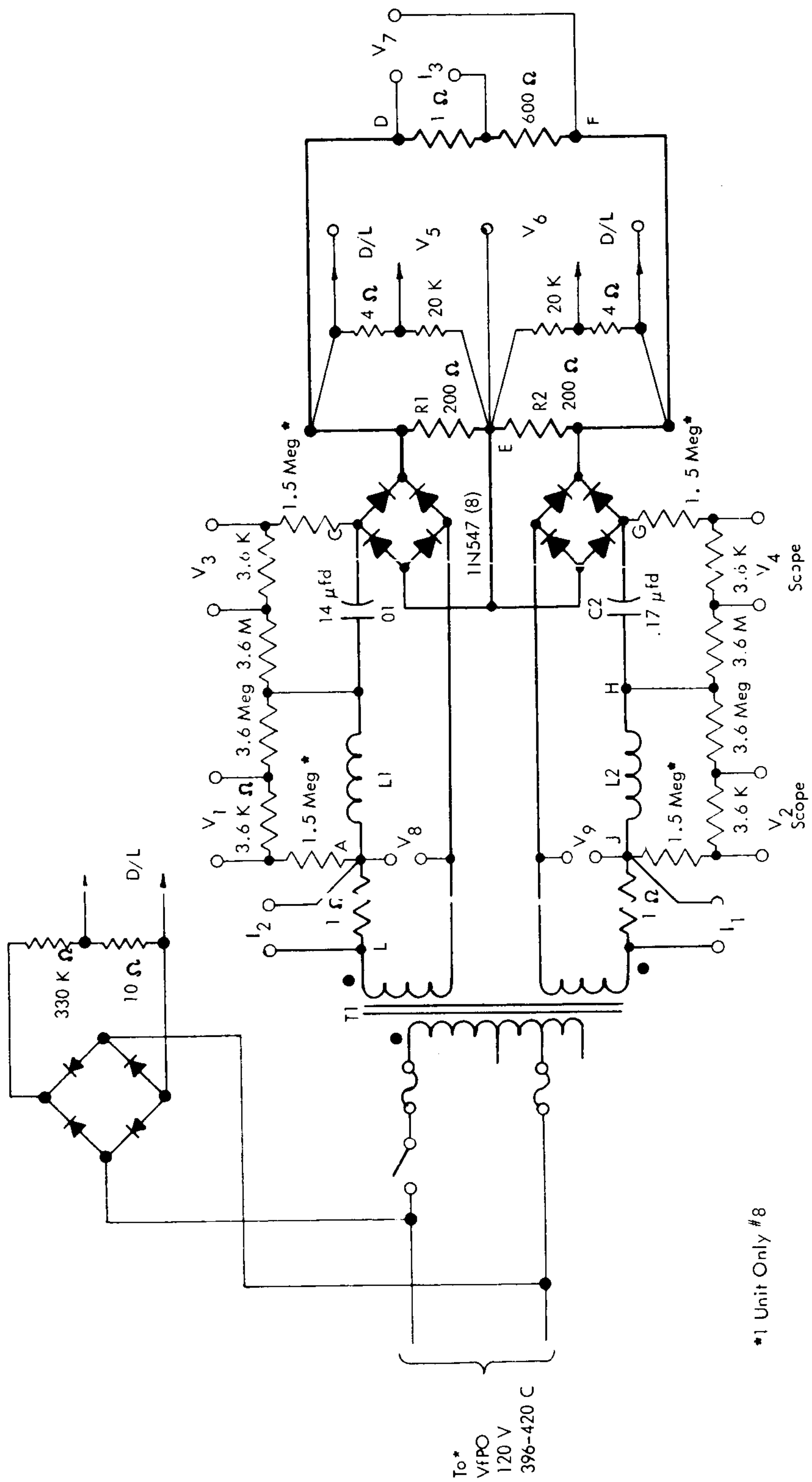


FIGURE 4 - 12 8 DIODE FREQUENCY SENSING

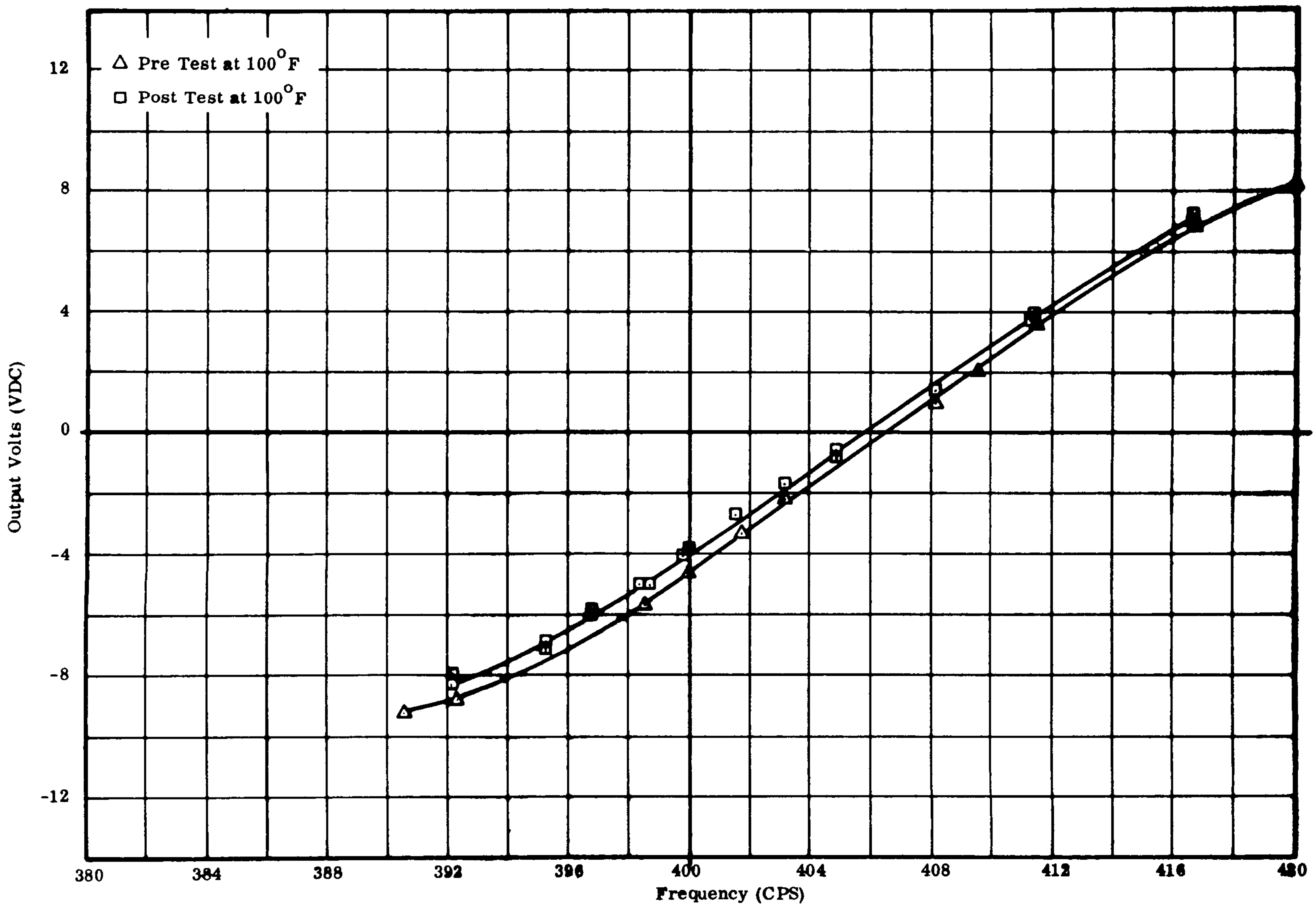


FIGURE 4-13 INPUT FREQUENCY VERSUS OUTPUT VOLTAGE, 8 DIODE FREQUENCY SENSOR (A1), PRE AND POST TEST AT REACTOR FACILITY

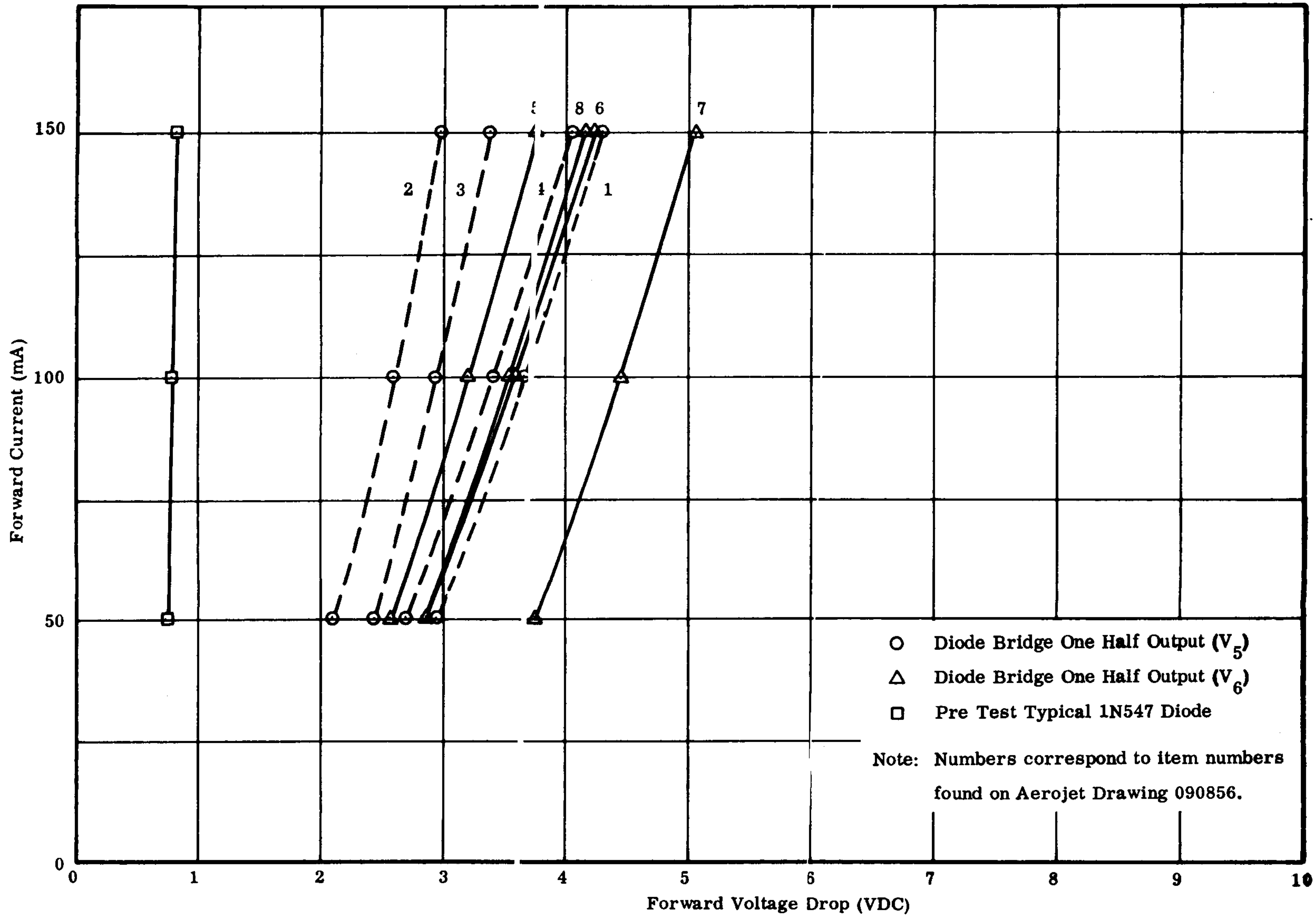
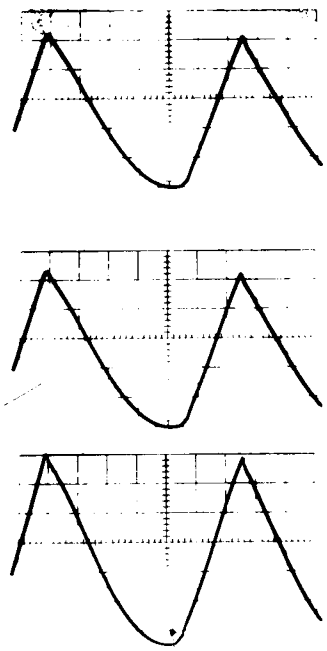


FIGURE 4-14 FORWARD CHARACTERISTICS, POST TEST (100° F), 1N547, DIODES REMOVED FROM 8 DIODE FREQUENCY SENSOR, SN#A1

Date: 7/17/64
Time: 1100 Hours



SN 1/V7

SN 2/V7

SN 6/V7

Sweep Speed: .2 m sec/cm
Gain: 5 V/cm

FIGURE 4 - 15 OUTPUT VOLTAGE OF TWO IRRADIATED AND ONE CONTROL 8 DIODE FREQUENCY SENSING SUB-ASSEMBLIES

TABLE 4-79 FUNCTIONAL PRE-TEST AT LABORATORY 8 DIODE FREQUENCY SENSOR

S/N	Null Frequency CPS	I_3 (MA) at Frequency (CPS)					
		412	420	427	387	392	400
A1	406	7.0	16.0	19.8	-21.0	-18.2	-9.2
A2	406	6.8	15.2	19.6	-19.8	-16.6	-7.2
A3	406	7.2	15.2	20.0	-20.4	-17.0	-7.4
A4	407	5.6	13.8	19.2	-20.4	-18.6	-9.2
A5	406	6.2	14.4	19.2	-20.6	-17.6	-8.2
A6	406	6.6	14.8	20.6	-20.6	-16.4	-6.6
A7	406	6.8	14.6	19.4	-20.0	-17.0	-7.0
A8	406	6.6	14.8	19.8	-20.0	-17.0	-7.4
A9	406	6.8	14.2	19.6	-19.8	-17.6	-6.4
A10	406	6.6	14.8	19.4	-19.8	-17.2	-7.4
A11	406	6.6	14.6	19.4	-20.0	-17.2	-7.2
A12	406	6.0	14.4	19.4	-19.6	-17.0	-8.0

TABLE 4-80 POST-TEST DATA AT LABORATORY 8 DIODE FREQUENCY SENSOR S/N A-1

F_1 (Frequency) CPS	Null 406	412	420	427	387	392	400
V1 (VAC)	240	290	350	380	139	160	202
V2 (VAC)	249	211	179	155	335	330	280
V3 (VAC)	266	315	360	380	168	188	231
V4 (VAC)	224	184	150	126	335	320	260
V5 (VDC)	16.79	18.84	21.28	22.23	13.03	13.99	15.54
V6 (VDC)	16.76	15.44	14.14	13.12	21.63	21.10	18.62
V7 (VDC)	0.0	3.37	7.13	9.12	-8.61	-7.10	-3.04
V8 (VAC)	36.1	36.0	35.9	35.6	36.1	36.5	36.2
V9 (VAC)	35.9	35.9	36.0	36.0	35.5	35.8	35.7
V10 (VAC)	120	120	120	120	120	120	120
I_1 (MA AC)	95	111	133	140	57	65	81
I_2 (MA AC)	94	79	65	56	136	130	110
I_3 (MA DC)	0.0	5.6	12.0	15.2	-14.4	-12.0	-5.0

TABLE 4-81 POST-TEST DATA AT LABORATORY 8 DIODE FREQUENCY SENSOR S/N A1 WITH A12 DIODES SUBSTITUTED

F_1 (Frequency) CPS	Null 406	412	420	427	387	392	400
V1 (VAC)	264	340	390	445	142	162	215
V2 (VAC)	279	239	202	173	405	395	330
V3 (VAC)	300	341	405	445	171	194	241
V4 (VAC)	250	210	171	142	407	385	310
V5 (VDC)	18.94	21.04	24.39	25.93	14.44	15.47	17.21
V6 (VDC)	18.93	17.30	15.84	14.61	25.95	25.36	21.60
V7 (VDC)	0.0	3.70	8.12	11.28	-11.48	-9.90	-4.36
V8 (VAC)	36.1	36.0	35.9	35.5	36.1	36.5	36.2
V9 (VAC)	35.9	35.9	36.0	36.0	35.5	35.5	35.6
V10 (VAC)	120	120	120	120	120	120	120
I_1 (MA AC)	105	125	150	165	59	69	88
I_2 (MA AC)	105	89	73	60	165	160	129
I_3 (MA DC)	0.0	-6.10	-13.6	-18.8	-19.2	-16.6	-7.2

TABLE 4-82 8 DIODE FREQUENCY SENSING S/N 1 PRE-TEST AT 100°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
2151	425.4	25.31	14.30	11.00
2156	416.7	22.70	15.95	6.75
2159	411.5	20.55	17.25	3.30
2203	408.2	19.40	18.30	1.10
2206	404.9	18.35	19.35	-1.00
2210	387.4	17.85	19.85	-2.00
2214	401.6	17.45	20.85	-3.40
2218	399.8	17.15	21.40	-4.25
2221	398.2	16.75	22.15	-5.40
2224	396.8	16.60	23.00	-.640
2226	395.3	16.30	23.60	-7.30
2228	392.2	15.75	24.40	-8.65
2230	389.3	15.05	25.60	-10.00
2232	384.5	14.40	25.00	-10.60

TABLE 4-83 8 DIODE FREQUENCY SENSING S/N 1 AT END OF LOW POWER RUN

Time	Input	Output dc Volts		
	Frequency CPS	Half Output V5	Half Output V6	Differential Output V7
2314	425.4	25.36	14.20	11.15
2318	416.7	23.20	16.25	6.95
2321	411.7	20.95	17.15	3.80
2326	408.2	19.70	18.30	1.40
2330	405.0	18.55	19.20	-.65
2335	403.4	18.10	19.60	-1.50
2338	401.6	17.65	20.65	-3.00
2342	399.8	17.30	21.15	-3.85
2345	398.6	17.00	21.75	-4.75
2347	396.8	16.70	22.60	-5.90
2349	395.1	16.35	23.15	-6.80
2351	392.2	16.10	24.45	-8.35
2353	389.1	15.60	24.75	-9.15
2356	384.6	14.65	25.00	-10.35

Neutron Exposure 5.13 (11) nvt
Gamma Dose 1.67 (6) Rads

TABLE 4-84 8 DIODE FREQUENCY SENSING S/N 1 AT END OF TEST WITH LiH SHIELD

Time	Input Frequency CPS	Output dc Volts Half Output V5	Half Output V6	Differential Output V7
1615	425.5	25.11	14.10	11.00
1619	416.8	22.85	15.75	7.10
1622	411.5	20.75	17.15	3.60
1626	408.0	19.45	18.30	1.15
1629	404.7	18.30	19.10	-.80
1633	403.1	17.90	19.60	-1.70
1636	401.8	17.60	20.35	-2.75
1640	399.8	17.15	21.20	-4.05
1643	398.4	16.90	21.75	-4.85
1646	396.8	16.60	22.55	-5.95
1648	395.3	16.30	23.05	-6.75
1657	392.3	15.90	24.20	-8.30
1700	389.0	15.60	25.00	-9.40
1702	384.6	14.45	24.65	-10.20

Neutron Exposure 1.2 (12) nvt
Gamma Dose 3.95 (6) Rads

TABLE 4-85 8 DIODE FREQUENCY SENSING S/N 1 POST-TEST AT $100^{\circ}F$

Time	Input	Output dc Volts		
	Frequency CPS	Half Output V5	Half Output V6	Differential Output V7
0927	425.5	21.40	12.60	8.80
0931	416.7	20.05	14.05	6.00
0935	411.5	18.50	14.95	3.55
0941	408.2	17.55	15.75	1.80
0948	404.9	16.55	16.40	.15
0953	403.2	16.25	16.65	-.40
0956	401.6	15.95	17.25	-1.30
1000	400.0	15.70	17.65	-1.95
1004	398.4	15.30	18.15	-2.85
1020	396.8	15.00	18.60	-3.60
1023	395.3	14.75	19.00	-4.25
1029	392.2	14.25	19.60	-5.35
1032	389.1	13.85	20.15	-6.30
1036	384.6	13.05	20.40	-7.35

Neutron Exposure 7.0 (13) nvt
Gamma Dose 6.3 (6) Rads

TABLE 4-86 8 DIODE FREQUENCY SENSING S/N 5 PRE-TEST AT 100°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
2151	425.4	25.76	14.30	11.46
2156	416.7	22.90	16.00	6.90
2159	411.5	21.00	17.25	3.75
2203	408.2	19.80	18.20	1.60
2206	404.9	18.60	19.45	-.85
2210	387.4	18.10	19.90	-1.80
2214	401.6	17.75	20.65	-2.90
2218	399.8	17.35	21.55	-4.20
2221	398.2	17.00	22.25	-5.25
2224	396.8	16.85	23.15	-6.30
2226	395.3	16.55	23.75	-7.20
2248	392.2	16.05	24.45	-8.40
2230	389.3	15.70	24.75	-9.05
2232	384.5	14.60	25.06	-10.46

TABLE 4-87 8 DIODE FREQUENCY SENSING S/N 5 AT END OF LOW POWER RUN

Time	Input Frequency CPS	Output ac Volts		
		Half Output V5	Half Output V6	Differential Output V7
2314	425.4	25.76	14.25	11.5
2318	416.7	23.50	16.25	7.25
2321	411.7	21.30	17.15	4.15
2326	408.2	20.10	18.30	1.80
2330	405.0	18.80	19.05	-.25
2335	403.4	18.35	19.70	-1.35
2338	401.6	17.95	20.70	-2.75
2342	399.8	17.50	21.30	-3.80
2345	398.6	17.25	21.95	-4.70
2347	396.8	16.85	22.65	-5.80
2349	395.1	16.60	23.30	-6.70
2351	392.2	16.40	24.60	-8.20
2353	389.1	15.75	25.06	-9.31
2356	384.6	14.85	25.11	-10.26

Neutron Exposure 4.14 (11) nvt
Gamma Dose 1.61 (6) Rads

TABLE 4-88 8 DIODE FREQUENCY SENSING S/N 5 AT END OF TEST WITH LiH SHIELD

Time	Input	Output dc Volts		
	Frequency CPS	Half Output V5	Half Output V6	Differential Output V7
1615	425.5	25.66	14.10	11.56
1619	416.8	23.05	15.80	7.25
1622	411.5	21.25	17.10	4.15
1626	408.0	19.90	18.25	1.65
1629	404.7	18.70	19.00	-.30
1633	403.1	18.20	19.65	-1.45
1636	401.8	17.85	20.25	-2.40
1640	399.8	17.45	21.25	-3.80
1643	398.4	17.10	21.85	-4.75
1646	396.8	16.90	22.70	-5.80
1648	395.3	16.55	23.20	-6.65
1657	392.3	16.25	24.30	-8.65
1700	389.0	15.40	24.70	-9.30
1702	384.6	14.70	24.70	-10.00

Neutron Exposure 9.7 (11) nvt
Gamma Dose 3.8 (6) Rads

TABLE 4-89 8 DIODE FREQUENCY SENSING S/N 5 POST-TEST AT 100°F

Time	Input Frequency CPS	Output dc Volts Half Output V5	Half Output V6	Differential Output V7
0927	425.5	21.95	12.75	9.20
0931	416.7	20.45	14.30	6.15
0935	411.5	19.00	15.30	3.70
0941	408.2	17.95	16.00	1.95
0948	404.9	16.95	16.80	.15
0953	403.2	16.60	17.10	-.50
0956	401.6	16.40	17.65	-1.25
1000	400.0	15.85	18.20	-2.35
1004	398.4	15.60	18.70	-3.10
1020	396.8	15.35	19.20	-3.85
1023	395.3	15.10	19.60	-4.50
1029	392.2	14.60	20.35	-5.75
1032	389.1	14.00	20.75	-6.75
1036	384.6	13.40	21.05	-7.65

Neutron Exposure 6.6 (13) nvt
Gamma Dose 6.1 (6) Rads

TABLE 4-90 8 DIODE FREQUENCY SENSING S/N 11 PRE-TEST AT 100°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
2151	425.4	25.36	14.25	11.10
2156	416.7	22.85	15.95	6.90
2159	411.5	20.75	17.25	3.50
2203	408.2	19.65	18.25	1.40
2206	404.9	18.55	19.25	-.70
2210	387.4	18.05	20.00	-1.95
2214	401.6	17.75	20.75	-3.00
2218	399.8	17.35	21.60	-4.25
2221	398.2	16.95	22.40	-5.45
2224	396.8	16.80	23.20	-6.40
2226	395.3	16.55	23.80	-7.25
2228	392.2	16.05	24.60	-8.55
2230	389.3	15.60	24.70	-9.10
2232	384.5	14.60	25.16	-10.55

TABLE 4-91 8 DIODE FREQUENCY SENSING S/N 11 AT END OF LOW POWER RUN

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
2314	425.4	25.46	14.20	11.25
2318	416.7	23.30	16.25	7.05
2321	411.7	21.25	17.15	4.10
2326	408.2	19.90	18.35	1.55
2330	405.0	18.75	19.05	-.30
2335	403.4	18.25	19.95	-1.70
2338	401.6	17.90	20.55	-2.65
2342	399.8	17.45	21.35	-3.90
2345	398.6	17.20	22.00	-4.80
2347	396.8	16.85	22.75	-5.90
2349	395.1	16.55	23.40	-6.85
2351	392.2	16.25	24.65	-8.40
2353	389.1	15.50	25.36	-9.85
2356	384.6	14.80	25.06	-10.25

Neutron Exposure 3.46 (11) nvt
Gamma Dose 1.23 (6) Rads

TABLE 4-92 8 DIODE FREQUENCY SENSING S/N 11 AT END OF TEST WITH LiH SHIELD

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
1615	425.5	25.16	14.05	11.10
1619	416.8	23.00	15.85	7.15
1622	411.5	20.95	17.10	3.85
1626	408.0	19.75	18.45	1.30
1629	404.7	18.55	19.25	-.70
1633	403.1	18.10	19.80	-1.70
1636	401.8	17.80	20.35	-2.55
1640	399.8	17.45	21.25	-3.80
1643	398.4	17.10	22.00	-4.90
1646	396.8	16.80	22.75	-5.95
1648	395.3	16.50	23.20	-6.70
1657	392.3	16.05	24.45	-8.40
1700	389.0	15.50	24.70	-9.20
1702	384.6	14.60	24.70	-10.10

Neutron Exposure 8.1 (11) nvt
Gamma Dose 2.9 (6) Rads

TABLE 4-93 8 DIODE FREQUENCY SENSING S/N 11 POST-TEST AT 100°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
0927	425.5	22.10	12.85	9.25
0931	416.7	20.65	14.45	6.20
0935	411.5	19.00	15.50	3.50
0941	408.2	18.00	16.40	1.60
0948	404.9	17.00	17.05	-.05
0953	403.2	16.65	17.35	-.70
0956	401.6	16.30	17.85	-1.55
1000	400.0	15.90	18.60	-2.70
1004	398.4	15.65	19.00	-3.35
1020	396.8	15.40	19.55	-4.15
1023	395.3	15.10	19.95	-4.85
1029	392.2	14.60	20.75	-6.15
1032	389.1	14.15	21.25	-7.10
1036	384.6	13.40	21.40	-8.00

Neutron Exposure 5.1 (13) nvt
Gamma Dose 4.65 (6) Rads

TABLE 4-94 8 DIODE FREQUENCY SENSING S/N 4 PRE-TEST AT 100°F

Time	Input Frequency CPS	Output dc Volts Half Output V5	Half Output V6	Differential Output V7
2151	425.4	25.46	14.60	10.85
2156	416.7	22.45	16.35	6.10
2159	411.5	20.60	17.60	3.00
2203	408.2	19.25	18.75	.50
2206	404.9	18.25	19.95	-1.70
2210	387.4	17.85	20.95	-3.10
2214	401.6	17.45	21.65	-4.20
2218	399.8	17.15	22.25	-5.10
2221	398.2	16.75	23.00	-6.25
2224	396.8	16.65	23.85	-7.20
2226	395.3	16.30	24.40	-8.10
2228	392.2	15.65	24.95	-9.30
2230	389.3	15.25	24.85	-9.60
2232	384.5	14.25	24.80	-10.55

TABLE 4-95 8 DIODE FREQUENCY SENSING S/N 4 AT END OF LOW POWER RUN

Time	Input Frequency CPS	Output dc Volts: Half Output V5	Output dc Volts: Half Output V6	Output dc Volts: Differential Output V7
2314	425.4	25.36	14.45	10.90
2318	416.7	22.95	16.50	6.45
2321	411.7	20.75	17.55	3.20
2326	408.2	19.50	18.70	.80
2330	405.0	18.45	19.90	-1.45
2335	403.4	18.00	20.35	-2.35
2338	401.6	17.55	21.30	-3.75
2342	399.8	17.20	22.00	-4.80
2345	398.6	16.90	22.50	-5.60
2347	396.8	16.55	23.25	-6.70
2349	395.1	16.25	23.75	-7.50
2351	392.2	16.05	24.85	-8.80
2353	389.1	15.10	25.21	-10.10
2356	384.6	14.35	24.70	-10.35

Neutron Exposure 8.97 (11) nvt
Gamma Dose 1.06 (6) Rads

TABLE 4-96 8 DIODE FREQUENCY SENSING S/N 4 AT END OF TEST WITH LiH SHIELD

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
1615	425.5	24.85	14.25	10.60
1619	416.8	22.35	16.00	6.35
1622	411.5	20.30	17.40	3.10
1626	408.0	19.25	18.70	.55
1629	404.7	18.15	19.45	-1.30
1633	403.1	17.70	20.20	-2.50
1636	401.8	17.35	20.90	-3.55
1640	399.8	16.95	21.70	-4.75
1643	398.4	16.70	22.25	-5.55
1646	396.8	16.45	23.00	-6.55
1648	395.3	16.15	23.40	-7.25
1657	392.3	15.70	24.40	-8.70
1700	389.0	15.10	24.40	-9.30
1702	384.6	14.20	24.20	-10.00

Neutron Exposure 2.1 (12) nvt
Gamma Dose 2.5 (6) Rads

TABLE 4-97 8 DIODE FREQUENCY SENSING S/N 4 POST-TEST AT 100°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
0927	425.5	20.75	12.65	8.10
0931	416.7	19.35	14.25	5.10
0935	411.5	18.00	15.20	2.80
0941	408.2	17.10	16.00	1.10
0948	404.9	16.25	16.70	-.45
0953	403.2	15.90	17.15	-1.25
0956	401.6	15.60	17.45	-1.85
1000	400.0	15.50	18.20	-2.70
1004	398.4	15.05	18.50	-3.45
1020	396.8	14.75	18.90	-4.15
1023	395.3	14.45	19.20	-4.75
1029	392.2	14.00	19.80	-5.80
1032	389.1	13.70	20.20	-6.50
1036	384.6	12.85	20.15	-7.30

Neutron Exposure 6.4 (13) nvt
Gamma Dose 3.96 (6) Rads

TABLE 4-98 CONTROL 8 DIODE FREQUENCY SENSING S/N 2 PRE-TEST AT 100°F

Time	Input	Output dc Volts		
	Frequency CPS	Half Output V5	Half Output V6	Differential Output V7
2152	425.4	25.51	14.45	11.05
2156	416.7	23.25	16.25	7.00
2200	411.5	21.20	17.50	3.70
2203	408.2	20.00	18.70	1.30
2207	404.9	18.90	19.50	-.60
2210	387.4	18.35	20.55	-2.20
2214	401.6	18.00	20.85	-2.85
2218	399.8	17.60	21.65	-4.05
2222	398.2	17.25	22.55	-5.30
2224	396.8	17.05	23.40	-6.35
2226	395.3	16.75	24.05	-7.30
2228	392.2	16.10	24.80	-8.70
2230	389.3	15.65	25.11	-9.45
2233	384.5	14.75	25.41	-10.65

TABLE 4-99 CONTROL 8 DIODE FREQUENCY SENSING S/N 2 POST-TEST AT 100°F

Time	Input Frequency CPS	Output dc Volts Half Output V5	Half Output V6	Differential Output V7
0927	425.5	25.76	14.55	11.20
0932	416.7	23.70	16.45	7.25
0936	411.5	21.40	17.60	3.80
0941	408.2	20.20	18.80	1.40
0948	404.9	18.95	19.75	-.80
0953	403.2	18.55	20.30	-1.75
0957	401.6	18.15	20.80	-2.65
1001	400.0	17.90	21.65	-3.75
1005	398.4	17.45	22.45	-5.00
1020	396.8	17.10	23.05	-5.95
1024	395.3	16.85	23.75	-6.90
1029	392.2	16.40	24.70	-8.30
1032	389.1	15.85	25.16	-9.30
1036	384.6	14.85	25.36	-10.50

TABLE 4-100 CONTROL 8 DIODE FREQUENCY SENSING S/N 6 PRE-TEST AT 100°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
2152	425.4	25.81	14.35	11.46
2156	416.7	22.70	15.80	6.90
2200	411.5	20.80	16.90	3.90
2203	408.2	19.40	17.90	1.50
2207	404.9	18.40	18.65	-.25
2210	387.4	17.80	19.35	-1.55
2214	401.6	17.45	20.00	-2.55
2218	399.8	17.15	20.75	-3.60
2222	398.2	16.70	21.55	-4.85
2224	396.8	16.55	22.40	-5.85
2226	395.3	16.30	23.10	-6.80
2228	392.2	15.75	24.15	-8.40
2230	389.3	15.10	25.00	-9.90
2233	384.5	14.60	25.41	-10.81

TABLE 4-101 CONTROL 8 DIODE FREQUENCY SENSING S/N 6 POST-TEST AT 100°F

Time	Input Frequency CPS	Output dc Volts Half Output V5	Half Output V6	Differential Output V7
0927	425.5	26.11	14.40	11.71
0932	416.7	23.15	16.00	7.15
0936	411.5	20.95	17.00	3.95
0941	408.2	19.45	18.05	1.40
0948	404.9	18.45	18.80	-.35
0953	403.2	17.95	19.30	-1.35
0957	401.6	17.55	19.95	-2.40
1001	400.0	17.35	20.85	-3.50
1005	398.4	16.90	21.50	-4.60
1020	396.8	16.55	22.20	-5.65
1024	395.3	16.35	22.90	-6.55
1029	392.2	15.90	24.00	-8.10
1032	389.1	15.60	24.75	-9.15
1036	384.6	14.75	25.36	-10.61

TABLE 4-102 8 DIODE FREQUENCY SENSING S/N 7 PRE-TEST AT 160°F

Time	Input Frequency CPS	Output dc Volts Half Output V5	Half Output V6	Differential Output V7
1503	390.0	15.40	24.35	-8.95
1505	410.0	20.50	17.50	3.00
1506	420.2	24.30	15.10	9.20
1921	394.9	16.65	23.40	-6.75
1923	400.0	17.75	21.15	-3.40
1924	405.0	18.90	19.15	- .25
1925	415.1	22.60	16.30	6.30

TABLE 4-103 8 DIODE FREQUENCY SENSING S/N 7 AT END OF LOW POWER RUN

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
1053	425.5	25.56	14.15	11.40
1057	416.5	23.40	15.95	7.45
1101	411.5	21.35	17.05	4.30
1104	404.7	18.95	19.05	-.10
1108	400.8	17.90	20.65	-2.75
1112	395.9	16.90	23.05	-6.15
1116	392.2	16.15	24.35	-8.20
1119	386.1	15.20	25.21	-10.00

Neutron Exposure 5.56 (11) nvt
Gamma Dose 1.81 (6) Rads

TABLE 4-104 8 DIODE FREQUENCY SENSING S/N 7 POST-TEST AT 160°F

Time	Input Frequency CPS	Output dc Volts Half Output V5	Half Output V6	Differential Output V7
0155	416.7	23.50	15.80	7.70
0159	413.1	21.85	16.50	5.35
0202	409.8	20.65	17.35	3.30
0203	406.7	19.60	18.55	1.05
0204	403.2	18.55	19.40	-.85
0205	400.0	17.80	20.85	-3.05
0206	396.8	17.05	22.50	-5.45
0208	393.5	16.50	23.85	-7.35
0209	390.6	16.15	24.70	-8.55
0210	387.6	15.40	25.06	-9.65
0211	384.3	14.80	24.95	-10.15

Neutron Exposure 1.2 (12) nvt
Gamma Dose 3.95 (6) Rads

TABLE 4-105 8 DIODE FREQUENCY SENSING S/N 8 PRE-TEST AT 160°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
1503	390.0	15.40	25.36	-9.96
1505	410.0	20.65	17.30	3.35
1506	420.2	24.40	15.15	9.25
1921	394.9	16.55	23.20	-6.65
1923	400.0	17.55	20.95	-3.40
1924	405.0	19.05	19.00	0.05
1925	415.1	22.70	16.35	6.35

TABLE 4-106 8 DIODE FREQUENCY SENSING S/N 8 AT END OF LOW POWER RUN

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
1053	425.5	26.01	14.30	11.31
1057	416.5	23.50	16.00	7.50
1101	411.5	21.50	17.00	4.50
1104	404.7	19.00	19.00	0.0
1108	400.8	17.90	20.50	-2.60
1112	395.9	16.80	22.75	-5.95
1116	392.2	16.15	24.30	-8.15
1119	386.1	14.95	25.41	-10.46

Neutron Exposure 4.5 (11) nvt
Gamma Dose 1.74 (6) Rads

TABLE 4-107 8 DIODE FREQUENCY SENSING S/N 8 POST-TEST AT 160°F

Time	Input	Output dc Volts		
	Frequency CPS	Half Output V5	Half Output V6	Differential Output V7
0155	416.7	23.70	15.95	7.75
0159	413.1	22.15	16.06	6.09
0202	409.8	20.85	17.40	3.45
0203	406.7	19.80	18.35	1.45
0204	403.2	18.65	19.40	-.75
0205	400.0	17.80	20.75	-2.95
0206	396.8	17.05	22.30	-5.25
0208	393.5	16.45	23.70	-7.25
0209	390.6	15.90	24.55	-8.65
0210	387.6	15.30	25.31	-10.01
0211	384.3	14.60	25.21	-10.61

Neutron Exposure 9.7 (11) nvt
Gamma Dose 3.8 (6) Rads

TABLE 4-108 8 DIODE FREQUENCY SENSING S/N 9 PRE-TEST AT 160°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
1503	390.0	15.60	25.66	-10.05
1505	410.0	20.25	17.40	2.85
1506	420.2	24.20	15.05	9.15
1921	394.9	16.60	23.45	-6.85
1923	400.0	17.55	21.40	-3.85
1924	405.0	18.55	19.10	-.55
1925	415.1	22.45	16.30	6.15

TABLE 4-109 8 DIODE FREQUENCY SENSING S/N 9 AT END OF LOW POWER RUN

Time	Input	Output dc Volts		
	Frequency CPS	Half Output V5	Half Output V6	Differential Output V7
1053	425.5	25.51	14.20	11.30
1057	416.5	23.20	16.05	7.15
1101	411.5	21.15	17.10	4.05
1104	404.7	18.85	19.25	-.40
1108	400.8	17.80	20.90	-3.10
1112	395.9	16.80	23.25	-6.45
1116	392.2	16.10	24.45	-8.35
1119	386.1	15.05	25.16	-10.11

Neutron Exposure 3.76 (11) nvt
Gamma Dose 2.78 (6) Rads

TABLE 4-110 8 DIODE FREQUENCY SENSING S/N 9 POST-TEST AT 160°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
0155	416.7	23.30	15.90	7.40
0159	413.1	21.70	16.70	5.00
0202	409.8	20.50	17.55	2.95
0203	406.7	19.40	18.70	.70
0204	403.2	18.45	20.00	-1.55
0205	400.0	17.70	21.35	-3.65
0206	396.8	17.00	22.85	-5.85
0208	393.5	16.50	24.20	-7.70
0209	390.6	16.20	24.85	-8.65
0210	387.6	15.40	25.26	-9.85
0211	384.3	14.70	24.90	-10.20

Neutron Exposure 8.1 (11) nvt
Gamma Dose 2.9 (6) Rads

TABLE 4-111 8 DIODE FREQUENCY SENSING S/N 10 PRE-TEST AT 160°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
1503	390.0	15.65	25.96	-10.30
1505	410.0	20.50	17.40	3.10
1506	420.2	24.20	15.30	8.90
1921	394.9	16.60	23.30	-6.70
1923	400.0	17.45	21.00	-3.55
1924	405.0	18.75	19.20	-.45
1925	415.1	22.60	16.25	6.35

TABLE 4-112 8 DIODE FREQUENCY SENSING S/N 10 AT END OF LOW POWER RUN

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
1053	425.5	25.56	14.05	11.50
1057	416.5	23.25	15.85	7.40
1101	411.5	21.35	17.00	4.35
1104	404.7	18.90	18.95	-.05
1108	400.8	17.75	20.75	-3.00
1112	395.9	16.75	22.90	-6.15
1116	392.2	16.15	24.25	-8.10
1119	386.1	15.05	25.16	-10.10

Neutron Exposure 9.75 (11) nvt
Gamma Dose 2.78 (6) Rads

TABLE 4-113 8 DIODE FREQUENCY SENSING S/N 10 POST-TEST AT 160°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
0155	416.7	23.30	15.70	7.50
0159	413.1	21.85	16.40	5.45
0202	409.8	20.65	17.25	3.40
0203	406.7	19.60	18.45	1.15
0204	403.2	18.50	19.35	-.85
0205	400.0	17.75	20.80	-3.05
0206	396.8	17.00	22.35	-5.35
0208	393.5	16.45	23.70	-7.25
0209	390.6	15.85	24.50	-8.65
0210	387.6	15.35	25.00	-9.65
0211	384.3	14.70	24.85	-10.15

Neutron Exposure 2.1 (12) nvt
Gamma Dose 2.5 (6) Rads

TABLE 4-114 CONTROL 8 DIODE FREQUENCY SENSING S/N 3 PRE-TEST AT 160°F

Time	Input FREQUENCY CPS	Output dc Volts Half Output V5	Half Output V6	Differential Output V7
1504	390.0	15.65	24.35	-8.70
1505	410.0	20.05	17.45	2.60
1506	420.2	23.85	15.25	8.60
1921	394.9	16.40	23.55	-7.15
1923	400.0	17.20	21.30	-4.10
1925	405.0	18.45	19.20	-.75
1926	415.1	22.05	16.45	5.60

TABLE 4-115 CONTROL 8 DIODE FREQUENCY SENSING S/N 3 POST-TEST AT 160°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
0156	416.7	23.30	15.80	7.50
0200	413.1	21.70	16.50	5.20
0202	409.8	20.50	17.35	3.15
0203	406.7	19.40	18.45	.95
0204	403.2	18.35	19.55	-1.20
0206	400.0	17.65	20.60	-2.95
0207	396.8	16.95	22.35	-5.40
0208	393.5	16.45	23.75	-7.30
0209	390.6	15.95	24.65	-8.70
0210	387.6	15.45	25.36	-9.90
0212	384.3	14.85	25.31	-10.46

TABLE 4-116 CONTROL 8 DIODE FREQUENCY SENSING S/N 12 PRE-TEST AT 160°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
1504	390.0	16.10	25.76	-9.66
1505	410.0	20.40	17.95	2.45
1506	420.2	24.20	15.90	8.30
1921	394.9	16.70	24.00	-7.30
1923	400.0	17.55	21.80	-4.25
1925	405.0	18.85	19.75	-.90
1926	415.1	22.50	16.70	5.80

TABLE 4-117 CONTROL 8 DIODE FREQUENCY SENSING S/N 12 POST-TEST AT 160°F

Time	Input Frequency CPS	Output dc Volts		
		Half Output V5	Half Output V6	Differential Output V7
0156	416.7	23.80	16.15	7.65
0200	413.1	22.35	16.90	5.45
0202	409.8	21.05	17.85	3.20
0203	406.7	19.95	18.95	1.00
0204	403.2	18.90	19.95	-1.05
0206	400.0	18.15	21.30	-3.15
0207	396.8	17.40	23.10	-5.70
0208	393.5	16.75	24.35	-7.60
0209	390.6	16.30	25.06	-8.76
0210	387.6	15.55	25.46	-9.91
0212	384.3	14.90	25.21	-10.31

TABLE 4-118 TOTAL IRRADIATION DATA FOR 8 DIODE FREQUENCY SENSING SUBASSEMBLIES

Serial Number	Neutron nvt $\times 10^{-13}$	Gamma Rads $\times 10^{-6}$
1	7.0	6.3
5	6.6	6.1
11	5.1	4.65
4	6.4	3.98
7	.12	3.95
8	.097	3.8
9	.081	2.9
10	.21	2.5

4.4 MAGNETIC AMPLIFIER

The output and control characteristics of the magnetic amplifier showed little effect in the 160°F test. The results up to an equivalent dose in the 100°F test agreed well with those from the 160°F test, therefore, there was no effect due to temperature on the group of specimens up to this level of exposure. The characteristics noted from the automatic data system show a change in the low output end of the control-output characteristic curve. This change appeared to result from a coupling to ground in the L & N recorder used in the automatic system. The capacitive coupling to ground in the recorder delayed the resetting of the magnetic circuit of the saturable reactors causing some output to be observed when the control current should have produced a low output. Backup data taken during the 160°F run shows that without the coupling to ground the units did have a low output with the appropriate control currents. The remaining portion of the curve agrees quite well with that taken on the automatic system.

The additional exposure in the 100°F test caused extensive change in the control characteristics of the magnetic amplifiers, Figure 4-17. The maximum current output remained essentially constant, but decreased slightly due to the increased forward drop across diodes CR-1 and CR-2. The control current required to effect a given output increased appreciably.

After the test, Unit #1 was subjected to extensive bench tests to verify the results that had been obtained at the reactor. When the characteristic data had been taken, the diodes were replaced with diodes from a control unit. They were replaced in stages to determine the effect of each on the output of the circuit. Diode CR 1 and CR 2 were replaced initially and then Diode CR 3, a 1N2592 used to damp inductive reactance in the load, was replaced. Replacing CR 1 and CR 2 only had little effect. The control characteristics returned to normal after CR 3 was replaced.

Figure 4-18 shows oscillograph pictures of MA-1 during post bench test with a control current input that had been near the mid point of the curve. The lower photograph shows normal control restored after replacing the three diodes in the circuit. The data are shown in Tables 4-119 thru 4-127.

It can be seen from the diagram, Figure 4-16, that with an increased forward drop in CR 3, part of the discharge current from the load inductor must flow through the saturable reactor preventing it from resetting. Part of the current produced by the load inductor flows through the saturable reactor in opposition to the control current causing the control-output characteristics to be displaced in the direction of higher control currents, but having little effect on the slope of the "control" part of the curve. Bench tests wherein CR 3 and the inductive load were alternately and simultaneously replaced with equivalent resistors verified the analysis. As may be noted in the section of the SCR control and Trigger units, the mag amp circuit used to trigger the SCR's had a normal output at the end of the test. This is accounted for by the absence of the inductive load.

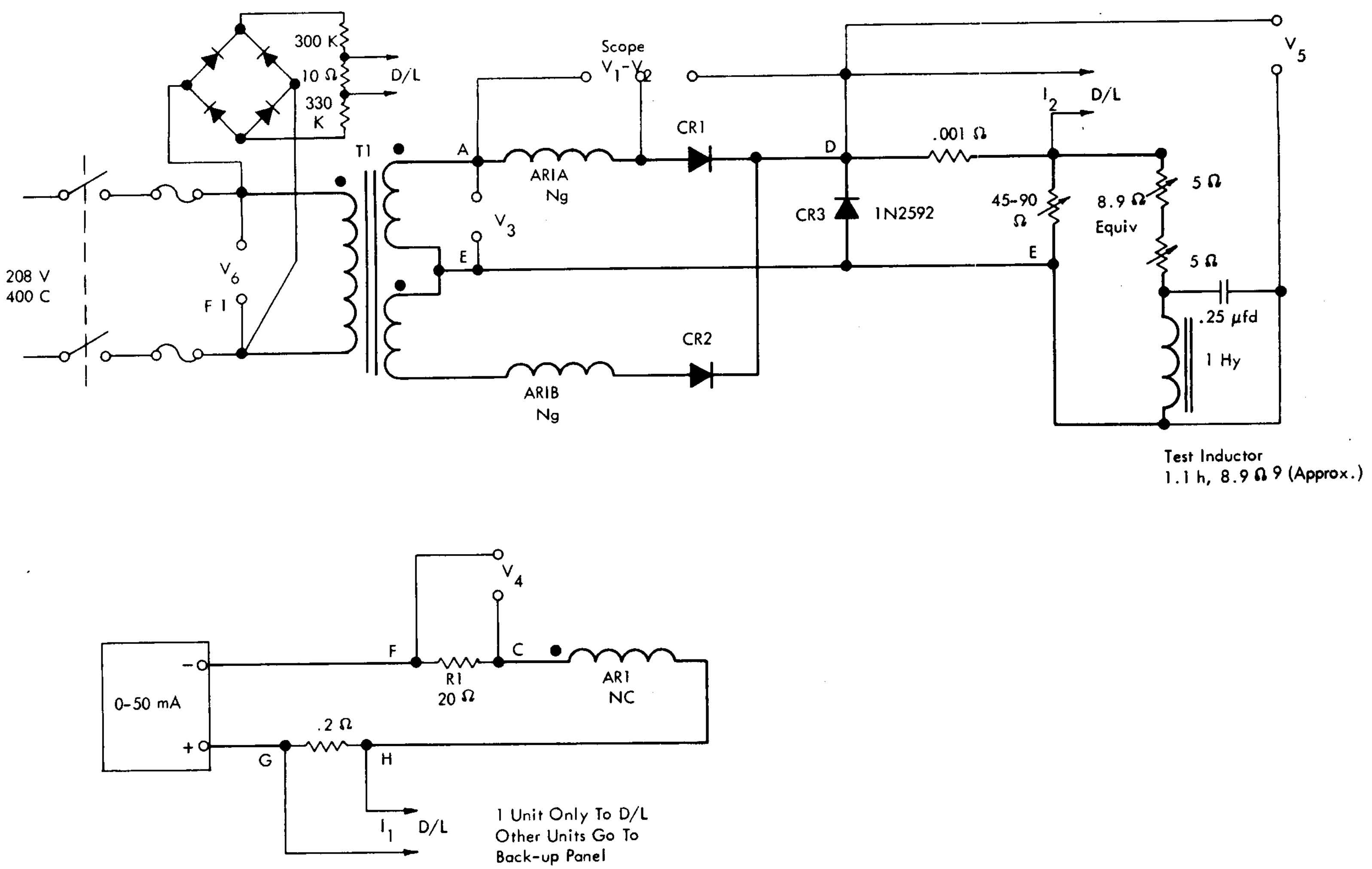


FIGURE 4 - 16 MAGNETIC AMPLIFIER

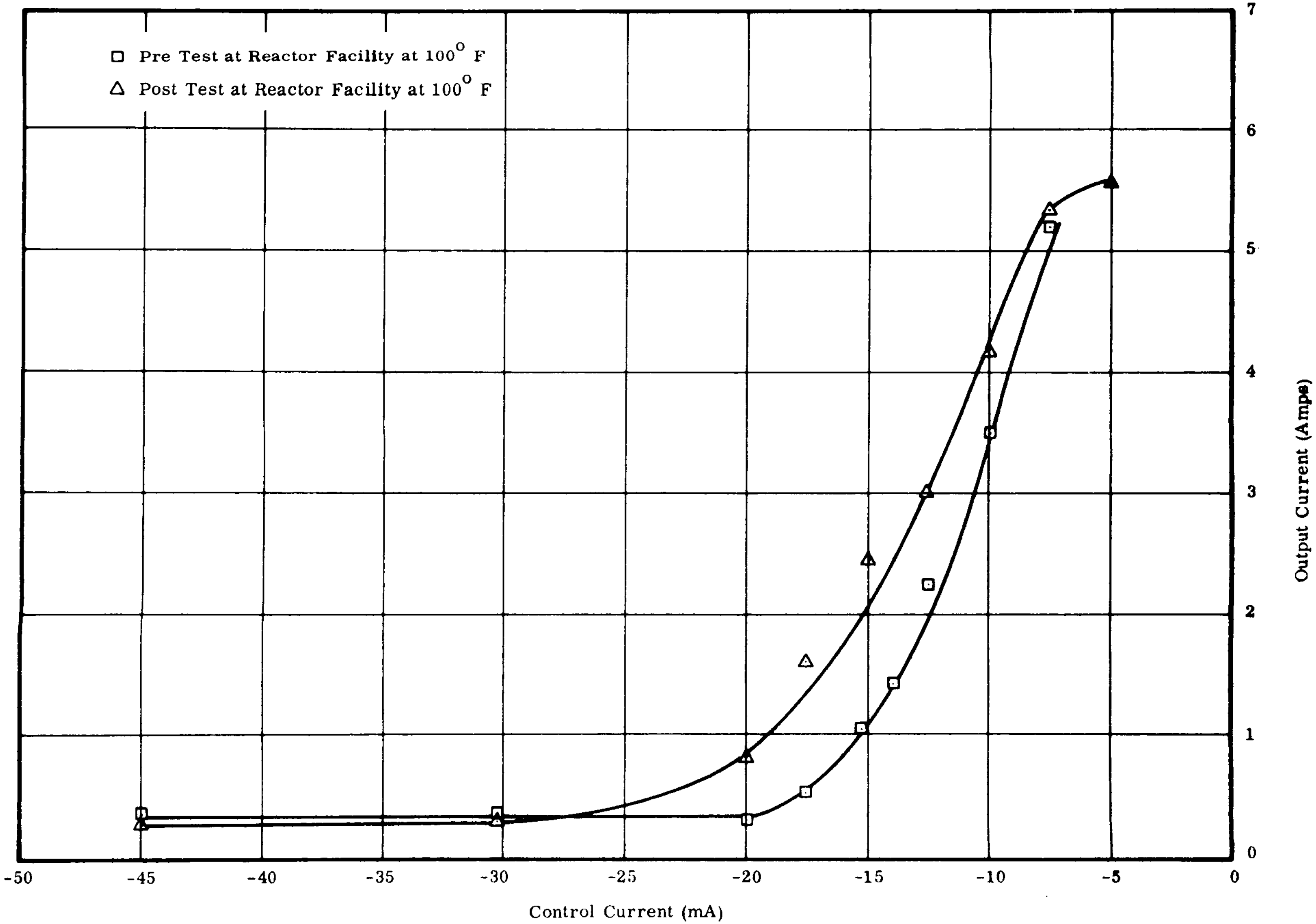
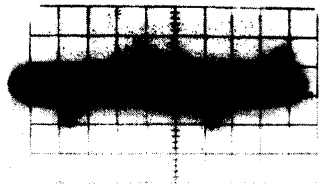
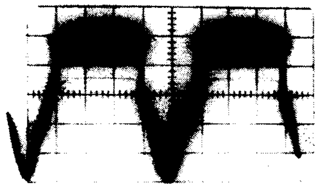


FIGURE 4-17 CONTROL CURRENT VERSUS OUTPUT CURRENT (PRE AND POST TEST, 100° F) MAGNETIC AMPLIFIER, SN#A1

Date: 7/17/64
Time: Post-Irradiation
Input: 14 MA



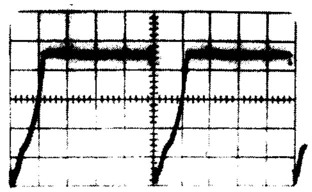
SN - 1/V1
Gain: 20 V/cm



SN - 1/V2
Gain: 50 V/cm

Before Diode Replacement

SN - 1/V1
Gain: 50 V/cm



SN - 1/V2
Gain: 50 V/cm

After Diode Replacement

Sweep Speed: 45 m sec/cm

FIGURE 4 - 18 POST BENCH TEST, MAGNETIC AMPLIFIER SN-1

TABLE 4-119 FUNCTIONAL PRE-TEST DATA 800 WATT MAGNETIC AMPLIFIER

S/N	Control Current (MA) For Zero Output	Output Current (A) For 14 MA Input	Output Current (A) With No Input
A1	35	4.2	7.3
A2	35	4.7	7.4
A3	28	4.2	7.4
A4	34	4.2	7.4
A5	33	4.2	7.3
A6	28	3.7	7.3
A7	29	3.8	7.3
A8	28	3.8	7.3
A9	34	4.2	7.4
A10	26	3.5	7.4
A11	26	3.4	7.4
A12	26	3.6	7.4

TABLE 4-120 PRE AND POST TEST DATA AT LABORATORY, 800 WATT MAGNETIC AMPLIFIER MODEL 091359-1-B S/N A1

Pre-Test At Laboratory								
Control Current I_1 (ma)	35	30	25	20	15	10	5	0
V3 (VAC)	82.0	82.0	81.5	81.0	81.0	79.0	79.0	79.0
V4 (VDC)	0.732	0.608	0.522	0.424	0.300	0.185	0.080	0.000
V5 (VDC)	2.7	2.7	3.0	17.3	37.8	59.0	66.2	66.2
I_2 (A)	0.2	0.3	0.3	1.9	4.2	6.7	7.3	0
Inductor Voltage	80	80	80	240	360	230	230	230
Post-Test At Laboratory								
Control Current I_1 (ma)	35	30	25	20	15	10	5	0
V3 (VAC)	78.0	78.0	78.0	78.0	78.0	78.0	79,0	79.0
V4 (VDC)	0.696	0.600	0.497	0.392	0.295	0.201	0.101	0.000
V5 (VDC)	58.70	59.94	61.26	62.86	64.00	64.52	64.78	64.90
I_2 (A)	6.0	6.1	6.6	6.7	6.7	6.7	6.6	6.9
Inductor Voltage	240	240	240	240	240	240	240	240
Post-Test at Laboratory with S/N A-11 Diodes Substituted					Control Current Required for Min. (0.3A) Output Current 150 ma.			
Control Current I_1 (ma)	35	30	25	20	15	10	5	0
V3 (VAC)	79.0	79.0	79.0	79.0	78.0	78.0	78.0	78.0
V4 (VDC)	0.703	0.599	0.496	0.399	0.296	0.200	0.106	0.000
V5 (VDC)	2.62	2.78	5.99	15.4	33.5	58.9	66.4	66.7
I_2 (A)	0.3	0.3	0.65	1.7	3.5	6.3	6.9	6.9
Inductor Voltage	120	130	150	210	258	230	240	240

TABLE 4-121 MAGNETIC AMPLIFIER S/N 1-6 PRE-TEST AT 100°F

Time	Input Control Current (Milliamp)	Output I_2 Amperes					
		S/N 1	S/N 2	S/N 3	S/N 4	S/N 5	S/N 6
2152	5.00	6.11	6.03	6.02	6.00	6.04	5.96
2157	7.55	4.45	4.31	4.78	4.79	4.50	4.35
2200	10.00	3.15	3.25	3.49	3.52	3.30	3.09
2204	12.55	1.74	1.94	2.22	2.22	1.95	1.69
2208	15.00	.94	1.04	1.26	1.29	1.08	.91
2211	17.45	.60	.54	.69	.73	.62	.56
2215	30.15	4.80	.41	.48	.52	.47	.50
2219	44.95	.48	.39	.48	.52	.45	.47

TABLE 4-122 MAGNETIC AMPLIFIER S/N 1-6 AT END OF LOW POWER RUN

Time	Input Control Current (Milliamp)	Output I_2 Amperes					
		S/N 1	S/N 2	S/N 3	S/N 4	S/N 5	S/N 6
0057	5.05	6.11	5.99	5.98	5.73	5.81	5.74
0102	7.55	4.58	4.55	4.95	4.89	4.32	4.20
0107	10.10	3.04	3.16	3.34	3.35	3.01	2.79
0125	12.50	1.67	1.93	2.15	2.17	1.84	1.55
0129	12.55	1.67	1.97	2.18	2.16	1.84	1.56
0134	15.00	.86	1.00	1.13	1.18	.97	.78
0142	17.60	.56	.54	.61	.66	.51	.50
0218	30.10	.41	.34	.44	.47	.38	.42
0223	45.20	.40	.33	.44	.45	.37	.40

Neutron Exposure	(nvt)	6.41 (11)	7.26 (11)	6.84 (11)	5.56 (11)
Gamma Dose	(Rads)	2.03 (6)	2.12 (6)	1.57 (6)	1.06 (6)

TABLE 4-123 MAGNETIC AMPLIFIER S/N 1-6 AT END OF TEST WITH LiH SHIELD

Time	Input Control Current (Milliamp)	Output I_2 Amperes					
		S/N 1	S/N 2	S/N 3	S/N 4	S/N 5	S/N 6
1616	5.05	6.09	6.02	6.00	5.95	6.02	5.95
1620	5.05	5.99	5.92	5.90	5.88	5.93	5.84
1624	9.95	3.11	3.24	3.44	3.53	3.15	2.94
1627	12.50	1.71	1.98	2.18	2.21	1.87	1.60
1630	15.10	.79	.91	1.09	1.12	.85	.70
1634	17.45	.49	.46	.58	.65	.45	.41
1637	30.20	.34	.28	.36	.39	.33	.36
1641	45.40	.35	.28	.37	.39	.31	.34
Neutron Exposure	(nvt)	1.5 (12)	1.7 (12)	1.6 (12)	1.3 (12)		
Gamma Dose	(Rads)	4.8 (6)	5.0 (6)	3.7 (6)	2.5 (6)		

TABLE 4-124 MAGNETIC AMPLIFIER S/N 1-6 POST TEST AT 100°F

Time	Input Control Current (Milliamp)	Output I_2 Amperes					
		S/N 1	S/N 2	S/N 3	S/N 4	S/N 5	S/N 6
0928	5.05	5.69	5.58	5.65	5.63	5.77	5.68
0932	7.60	5.54	5.43	5.47	5.59	4.28	4.11
0937	10.00	4.61	4.33	3.68	5.09	2.93	2.68
0942	12.55	3.58	3.40	2.66	4.19	1.79	1.56
0949	15.00	3.00	2.75	1.86	3.51	.95	.81
0954	17.50	2.24	2.09	1.33	3.01	.64	.64
0958	20.05	1.63	1.50	.89	2.57	.60	.60
1001	30.15	.59	.50	.61	.71	.60	.60
1005	45.35	.54	.47	.60	.59	.58	.60
Neutron Exposure	(nvt)	7.5 (13)	7.5 (13)	6.4 (13)	5.1 (13)		
Gamma Dose	(Rads)	7.6 (6)	7.95 (6)	5.9 (6)	4.0 (6)		

TABLE 4-125 MAGNETIC AMPLIFIER S/N 7-12 PRE-TEST AT 160°F

Time	Input Control Current (Milliamp)	Output I_2 Amperes					
		S/N 7	S/N 8	S/N 9	S/N 10	S/N 11	S/N 12
2203	0.0	6.28	6.45	6.49	6.51	6.65	6.57
2203	2.55	6.23	6.41	6.45	6.45	6.62	6.54
2203	4.95	6.14	6.35	6.38	6.39	6.54	6.48
2204	7.45	4.61	4.59	4.68	4.95	5.54	5.42
2204	10.00	2.80	3.01	2.98	3.41	3.69	3.83
2205	12.50	1.37	1.61	1.60	2.05	2.31	2.58
2205	15.00	.64	.75	.79	1.06	1.23	1.42
2206	17.55	.45	.48	.51	.58	.60	.73
2206	20.00	.41	.44	.45	.48	.43	.44
2207	30.05	.40	.43	.44	.44	.37	.38

TABLE 4-126 MAGNETIC AMPLIFIER S/N 7-12 AT END OF LOW POWER RUN

Time	Input Control Current (Milliamp)	Output I_2 Amperes					
		S/N 7	S/N 8	S/N 9	S/N 10	S/N 11	S/N 12
1011	4.95	6.18	6.19	6.19	6.17	6.25	6.23
1015	6.60	5.60	5.46	5.55	5.93	5.88	5.90
1019	9.50	3.12	3.19	3.16	3.59	3.52	3.59
1023	11.00	2.27	2.42	2.37	2.87	2.67	2.90
1027	12.50	1.38	1.55	1.53	2.03	1.83	2.03
1031	14.95	.65	.74	.74	1.04	.89	1.02
1034	30.20	.40	.43	.43	.43	.50	.51
1038	45.30	.39	.41	.43	.43	.50	.51
Neutron Exposure	(nvt)	6.95 (11)	7.88 (11)	7.42 (11)	6.04 (11)		
Gamma Dose	(Rads)	2.18 (6)	2.28 (6)	1.69 (6)	1.14 (6)		

TABLE 4-127 MAGNETIC AMPLIFIER S/N 7-12 POST-TEST AT 160°F

Time	Input Control Current (Milliamp)	Output I_2 Amperes					
		S/N 7	S/N 8	S/N 9	S/N 10	S/N 11	S/N 12
0246	2.55	6.59	6.74	6.75	6.74	6.73	6.69
0248	2.55	6.32	6.48	6.48	6.48	6.61	6.56
0253	5.00	6.27	6.58	6.61	6.60	6.56	6.54
0254	5.00	6.06	6.32	6.33	6.33	6.43	6.41
0258	7.55	4.58	4.68	4.71	5.31	5.27	5.12
0259	7.35	4.72	4.85	4.93	5.55	5.34	5.18
0305	7.55	4.56	4.63	4.67	5.23	5.18	5.00
0305	10.00	2.85	3.14	3.07	3.49	3.32	3.44
0306	12.50	1.47	1.71	1.68	2.12	1.92	2.11
0307	15.05	.68	.79	.82	1.07	.91	1.03
0307	20.05	.39	.41	.43	.45	.50	.52
0308	25.05	.37	.39	.40	.41	.48	.50
0308	30.00	.36	.39	.41	.41	.47	.50
Neutron Exposure	(nvt)	1.5 (12)	1.7 (12)	1.6 (12)	1.3 (12)		
Gamma Dose	(Rads)	4.8 (6)	5.0 (6)	3.7 (6)	2.5 (6)		

TABLE 4-128 TOTAL IRRADIATION DATA FOR MAGNETIC AMPLIFIER SUBASSEMBLIES

Serial Number	Neutron nvt (-13)	Gamma Rads (6)
1	7.5	7.6
2	7.5	7.95
3	6.4	5.9
4	5.1	4.0
7	.15	4.78
8	.17	5.0
9	.16	3.7
10	.13	2.5

4.5 SCR's TRIGGER AND CONTROL

Throughout the test difficulty was experienced in obtaining good data from the SCR Control subassemblies. The noise produced by the SCR components caused early triggering of the SCR subassembly panels. The data taken during the latter part of the 160°F test was with the SCR component 400 cps power turned off. The automatic system also produced an effect on the firing point of the units. The best results were obtained from manual data. These data were measured at the backup panel and then typed out on the flexowriter. The measurements were made on one panel at a time with all other SCR panels turned off. This procedure was developed during the 160°F test. This procedure was followed more closely throughout the 100°F test.

All units were operating at the end of the 160°F and at a comparable dose on the 100°F test. At the conclusion of the 100°F test serial numbers 3 and 4 had failed and serial number 1 had only one operating SCR. It is noted that serial number 1 and 2 were in a lower flux area. Their damage is consistent with serial numbers 3 and 4 at a similar dose.

The data are shown in Table 4-129 thru 4-135. Figures 4-20 thru 4-22 shows a sequence of oscilloscope pictures taken just prior to shutdown through completion of the post bench tests. Replacing the SCR's returned normal operation.

The output from the trigger units did change similar to other subassemblies using 1N547 but the control characteristics showed little change. Their output was still well above that required to trigger a normal SCR so that replacing their diodes had little or no effect on combined subassembly performance.

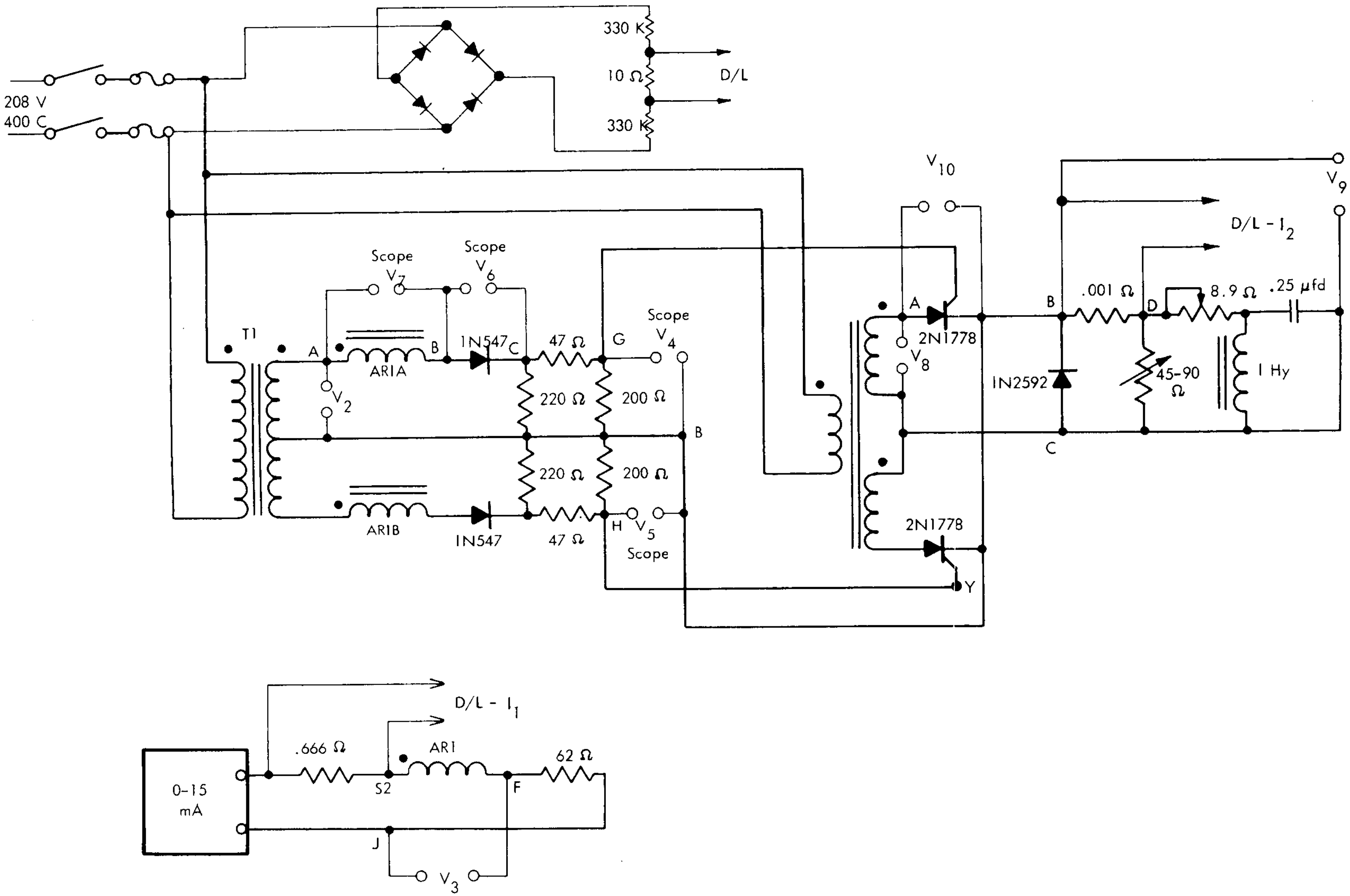
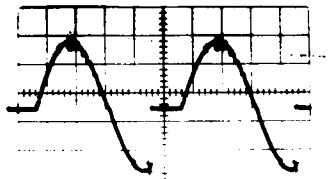
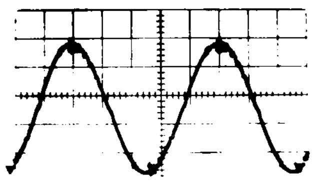


FIGURE 4-19 SCR CONTROL AND TRIGGER - TYPICAL CONNECTION DIAGRAM

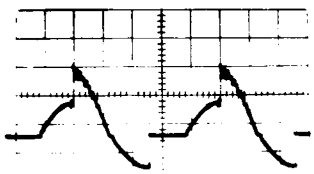
Date: 7/16/64
Time: 2240
Input: Mid-Range



SN - 1/V 10
Gain: 5 V/cm



SN - 3/V 10
Gain: 5 V/cm

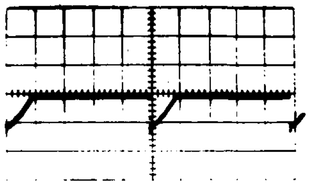


SN - 5/V 10
Gain: 10 V/cm

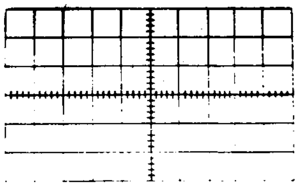
Sweep Speed: .5 m sec/cm

FIGURE 4 - 20 VOLTAGE DROP ACROSS 2N1778 NEAR END OF 100°F TEST

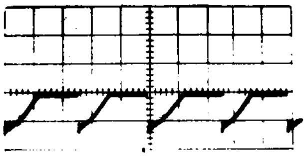
Date: 7/16/64
Time: 2320



SN - 1/V9

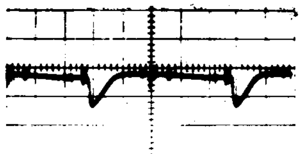


SN - 3/V9
(No Output)

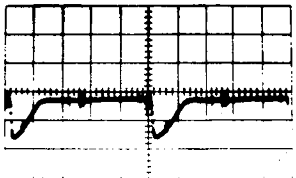


SN - 5/V9

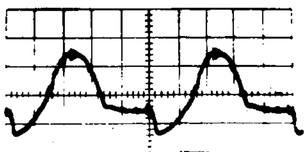
Sweep Speed: .5 m sec/ cm
Gain: 10 V / cm



SN - 3/V4



SN - 3/V5

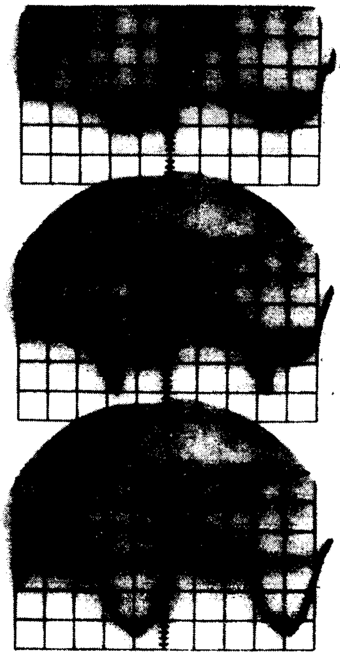


SN-3/V6

Sweep Speed: .5 m sec/cm
Gain: .5 V/cm

FIGURE 4 - 21 SELECTED S C R CONTROL WAVE TRACES NEAR END OF 100°F TEST

Date: Post Test
Time: Post Test
Input: 9.5 MA



SN - 1/V-6
Gain: 5 V/cm

SN - 1/V-7
Gain: 5 V/cm

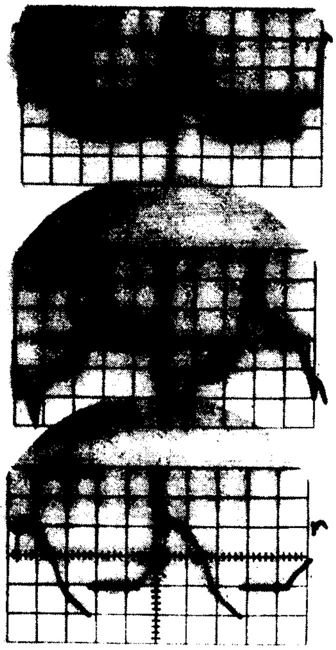
SN - 10/V-7
Gain: 50 V/cm

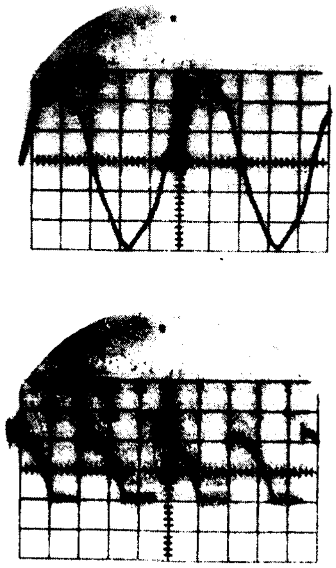
Before SCR and Diode Replacement

SN - 1/V6
Gain: 5 V/cm

SN -1/V-7
Gain: 5 V/cm

SN - 10/V-7
Gain: 100 V/cm





SN - 1/V1
Gain: 100 V/cm

SN - 1/V9
Gain: 50 V/cm

After SCR and Diode Replacement

Sweep Speed: .5 m sec/cm

FIGURE 4 - 22 POST BENCH TEST, SCR CONTROL, SN-1

TABLE 4-129 SCR CONTROL S/N 1-6 PRE-TEST AT 100°F

Time	Input Control Current (Milliamp)	Output I_2 Amperes					
		S/N 1	S/N 2	S/N 3	S/N 4	S/N 5	S/N 6
2251	2.99	5.80	5.90	5.60	5.90	5.90	6.10
2251	6.03	5.70	6.00	5.40	5.80	5.80	5.95
2253	7.50	5.60	5.60	5.15	5.60	5.60	5.70
2253	8.99	5.20	5.20	4.60	5.00	5.20	5.20
2254	10.48	4.04	4.10	3.30	3.70	3.80	3.80
2255	11.28	3.20	3.20	2.40	2.80	2.85	2.70
2256	12.01	2.20	2.10	1.50	1.80	1.80	1.60
2256	12.78	1.00	.80	.60	.80	.70	.50

3

TABLE 4-130 SCR CONTROL S/N 1-6 AT END OF LOW POWER RUN

Time	Input Control Current (Milliamp)	Output I_2 Amperes					
		S/N 1	S/N 2	S/N 3	S/N 4	S/N 5	S/N 6
2302	2.97	6.15	6.20	5.80	6.20	6.20	6.50
2303	6.02	6.95	6.00	5.60	6.10	6.10	6.30
2303	7.50	5.75	5.80	5.40	5.80	5,83	6.00
2304	8.99	5.30	5.40	4.80	5.20	5.30	5.35
2305	10.48	4.20	4.30	3.50	3.80	3.80	3.90
2306	11.28	3.20	3.30	3.60	2.80	2.80	2.70
2307	12.01	2.10	2.10	1.50	1.70	1.60	1.40
2307	12.75	.80	.80	.40	.60	.40	.20
SCR Control	nvt	3.78 (11)	3.78 (11)	3.87 (11)	3.89 (11)		
	Rads	1.23 (6)	1.23 (6)	1.77 (6)	1.77 (6)		
SCR Trigger	nvt	5.12 (11)	5.12 (11)	4.7 (11)	4.7 (11)		
	Rads	1.64 (6)	1.67 (6)	1.67 (6)	1.67 (6)		

Neutron Exposure (See above)

Gamma Dose (See above)

TABLE 4-131 SCR CONTROL S/N 1-6 AT END OF TEST WITH LiH SHIELD

Time	Input Control Current (Milliamp)	Output I_2 Amperes					
		S/N 1	S/N 2	S/N 3	S/N 4	S/N 5	S/N 6
1710	6.00	5.80	6.00	5.63	6.00	6.20	6.36
1711	7.50	5.60	5.80	5.40	5.80	6.00	6.05
1712	8.99	5.20	5.40	4.85	5.40	5.45	5.40
1712	10.51	4.20	4.40	3.60	4.00	4.10	4.00
1713	11.26	3.40	3.50	2.70	3.00	3.00	2.90
1714	11.98	2.30	2.40	1.60	1.90	1.80	1.60
1714	12.72	1.00	1.00	.40	.70	.60	.30
SCR Control	nvt	8.6 (11)	8.6 (11)	9.1 (11)	9.1 (11)		
	Rads	2.9 (6)	2.9 (6)	4.2 (6)	4.2 (6)		
SCR Trigger	nvt	1.2 (12)	1.2 (12)	1.1 (12)	1.2 (12)		
	Rads	3.87 (6)	3.89 (6)	3.94 (6)	3.94 (6)		

Neutron Exposure (See above)

Gamma Dose (See above)

TABLE 4-132 SCR CONTROL S/N 1-6 POST-TEST AT 100°F

Time	Input Control Current (Milliamp)	Output I_2 Amperes					
		S/N 1	S/N 2	S/N 3	S/N 4	S/N 5	S/N 6
1055	3.00	2.80	5.40			6.10	6.20
1101	6.00	2.70	5.20			6.00	6.00
1103	7.50	2.50	5.00			5.90	5.80
1104	9.00	2.30	4.70			5.40	5.30
1106	10.50	1.70	3.90			4.10	4.00
1108	11.25	1.25	3.10			3.20	3.10
1109	12.00	.85	2.00			2.10	1.90
110	12.75	.50				.85	.55
SCR Control	nvt	4.4 (14)	4.4 (13)	5.9 (13)	5.9 (13)		
	Rads	4.64 (6)	4.64 (6)	6.6 (6)	6.6 (6)		
SCR Trigger	nvt	6.3 (13)	6.3 (13)	7.0 (13)	7.0 (13)		
	Rads	6.16 (6)	6.16 (6)	6.3 (6)	6.3 (6)		

Neutron Exposure (See above)

Gamma Dose (See above)

TABLE 4-133 SCR CONTROL S/N 7-12 PRE-TEST AT 160°F

Time	Input Control Current (Milliamp)	Output I_2 Amperes					
		S/N 7	S/N 8	S/N 9	S/N 10	S/N 11	S/N 12
2211	5.99	5.52	5.94	5.67	5.25	5.54	5.92
2213	6.75	5.30	5.63	5.47	4.86	5.20	5.68
2214	7.50	5.05	5.42	5.25	4.36	4.74	5.41
2215	8.25	4.71	5.14	5.00	3.65	4.17	5.01
2216	9.02	4.23	4.75	4.64	2.80	3.45	4.49
2216	9.75	3.55	4.18	4.21	1.85	2.58	3.69
2217	10.50	2.60	3.29	3.48	.85	1.59	2.54
2218	11.23	1.55	2.21	2.50	.46	.57	1.26
2219	11.98	.51	1.07	1.39	.06	0.0	.15
2220	12.73	.05	.13	.40	.05	0.0	.04
2221	13.48	.06	.05	.04	.05	0.0	.04
2222	3.00	6.11	6.37	6.18	6.14	6.33	6.55
2223	1.51	6.30	6.51	6.29	6.39	6.48	6.69

TABLE 4-134 SCR CONTROL S/N 7-12 AT END OF LOW POWER RUN

Time	Input Control Current (Milliamp)	Output I_2 Amperes					
		S/N 7	S/N 8	S/N 9	S/N 10	S/N 11	S/N 12
1041	5.97	5.80	6.04	5.85	5.49	5.44	6.20
1042	8.70	4.87	5.27	5.01	3.61	3.12	5.69
1043	10.23	3.58	4.27	4.05	1.67	1.10	4.34
1044	11.71	1.47	2.33	2.25	.05	0.0	2.92
1045	12.33	.53	1.64	1.32	.05	0.0	2.89
1046	12.78	.05	1.33	.69	.05	0.0	2.91
1047	13.23	.06	1.21	.11	.06	0.0	2.89
1048	13.50	.07	1.27	.06	.06	0.0	2.89
1049	14.08	.06	1.37	.06	.06	0.0	2.90
SCR Control	nvt	3.99 (11)	3.99 (11)	4.22 (11)	4.22 (11)		
	Rads	1.32 (6)	1.32 (6)	1.90 (6)	1.90 (6)		
SCR Trigger	nvt	5.56 (11)	5.56 (11)	5.10 (11)	5.10 (11)		
	Rads	1.77 (6)	1.78 (6)	1.80 (6)	1.80 (6)		

Neutron Exposure See above

Gamma Dose See above

TABLE 4-135 SCR CONTROL S/N 7-12 POST-TEST AT 160°F

Time	Input Control Current (Milliamp)	Output I_2 Amperes					
		S/N 7	S/N 8	S/N 9	S/N 10	S/N 11	S/N 12
0334	6.00	5.78	6.02	5.84	5.54	5.49	5.74
0335	8.70	4.83	5.21	5.05	3.58	3.24	4.33
0335	10.20	3.54	4.03	4.17	1.60	1.22	2.25
0336	11.73	1.29	1.76	2.11	.07	0.0	-
0338	12.31	.33	.88	1.24	.06	0.0	-
0338	12.75	.06	.18	.60	.06	0.0	-
0339	13.21	.06	.05	.12	.07	0.0	-
0340	13.48	.06	.06	.07	.36	0.0	-
0384	7.74	5.15	5.45	5.35	4.57	4.24	5.22
SCR Control	nvt	8.6 (11)	8.6 (11)	9.1 (11)	9.1 (11)		
	Rads	2.9 (6)	2.9 (6)	4.2 (6)	4.2 (6)		
SCR Trigger	nvt	1.2 (12)	1.2 (12)	1.1 (12)	1.2 (12)		
	Rads	3.87(6)	3.89 (6)	3.94 (6)	3.9 (6)		

Neutron Exposure (See above)

Gamma Dose (See above)

5.0 NUCLEAR MEASUREMENTS

Figures 5-1 and 5-2 show the integrated fast neutron flux versus total elapsed time from start of test for Aerojet tests 2 and 3 respectively. These data were obtained from nickel foils that were irradiated for the duration of each test. Figures 5-5 and 5-6 show the fast neutron integrated flux distribution over the test panels for test 2 and 3 respectively.

Figure 5-3 and 5-4 show the gamma dose versus total elapsed time from start of test for test 2 and 3. These data were obtained from the two gamma monitors which were mounted outside the enclosure using the correlation between monitor dose rates and test panel dose rates obtained during the gamma mapping. Figure 5-7 shows the gamma dose distribution for tests 2 and 3 normalized to unity at the test panel centers. Within experimental accuracy the gamma dose distributions for test 2 and for test 3 are identical. Gamma spectrum results are reported in Volume 1, Gamma Spectrum Measurements.

Shielding during these tests consisted of 8" of water and 16" of LiH until the final portion of the 100°F run (3) when the LiH shield was removed.

Tables 5-1 and 5-2 show the accumulated exposure versus time for tests 2 and 3 respectively.

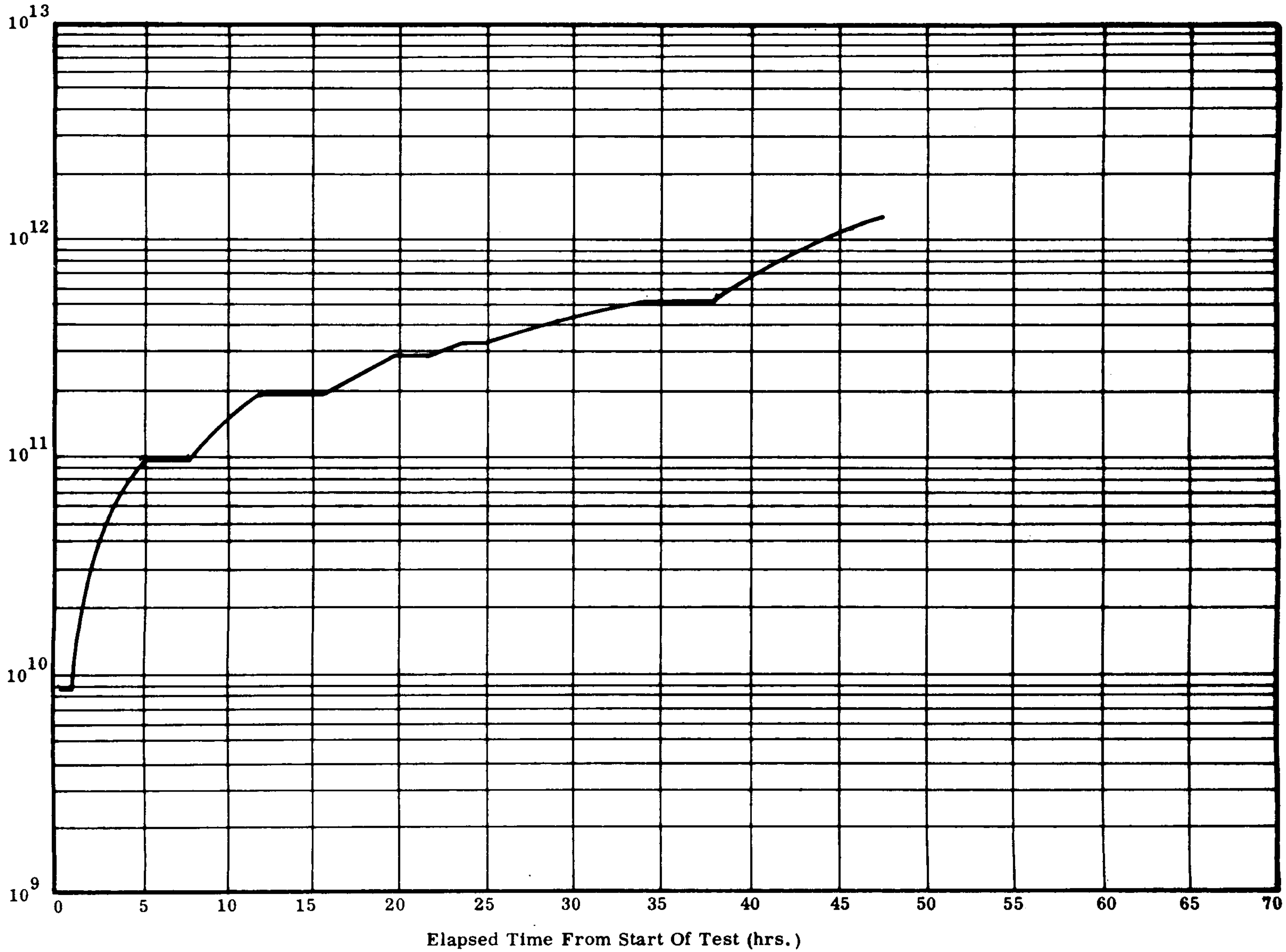


FIGURE 5-1 INTEGRATED NEUTRON FLUX (> 0.1 MeV) VERSUS TIME - AEROJET TEST 2, FOIL POSITION 884

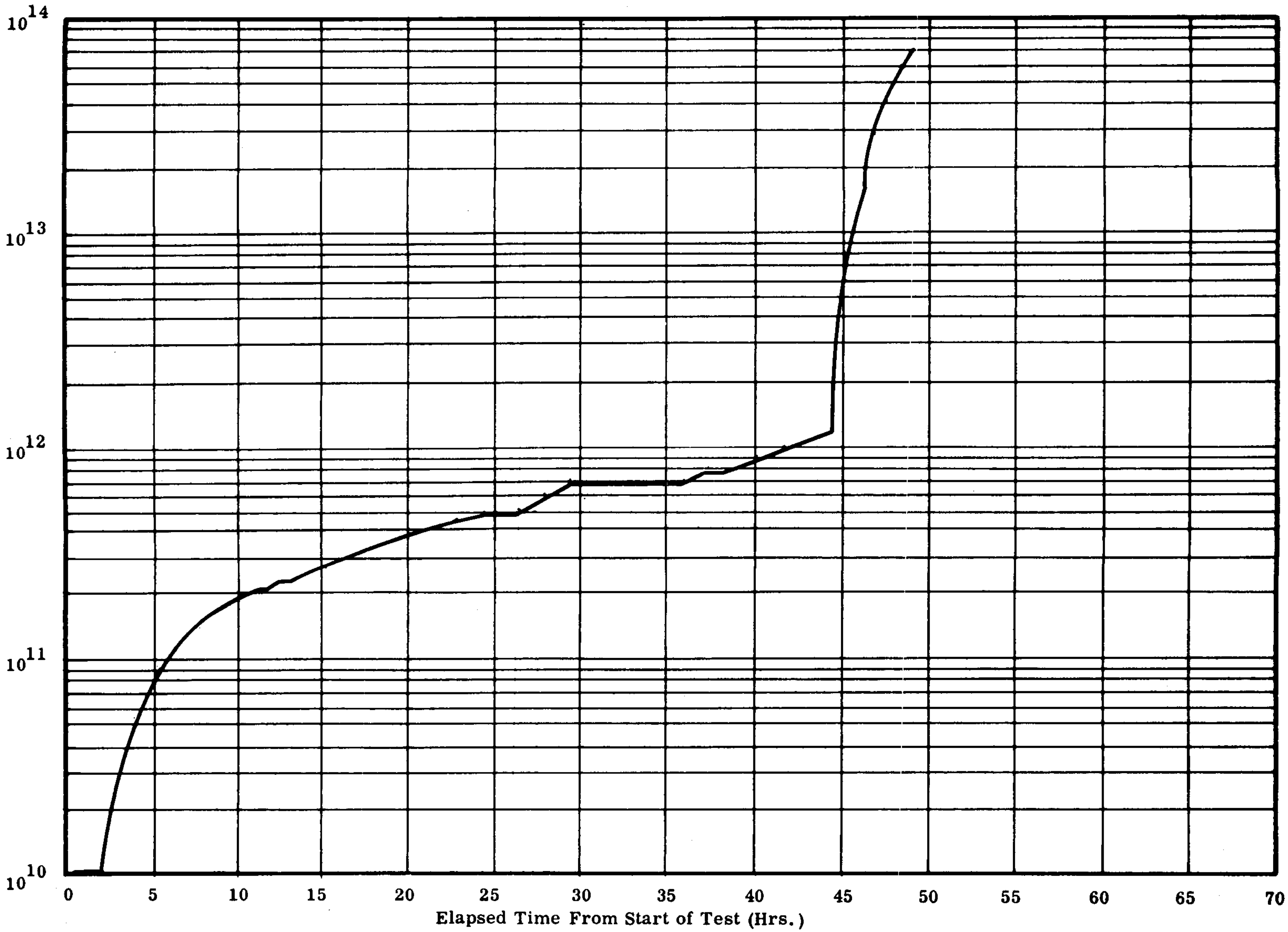


FIGURE 5-2 INTEGRATED NEUTRON FLUX (> 0.1 MeV) VERSUS TIME - AEROJET TEST 3, FOIL POSITION 786

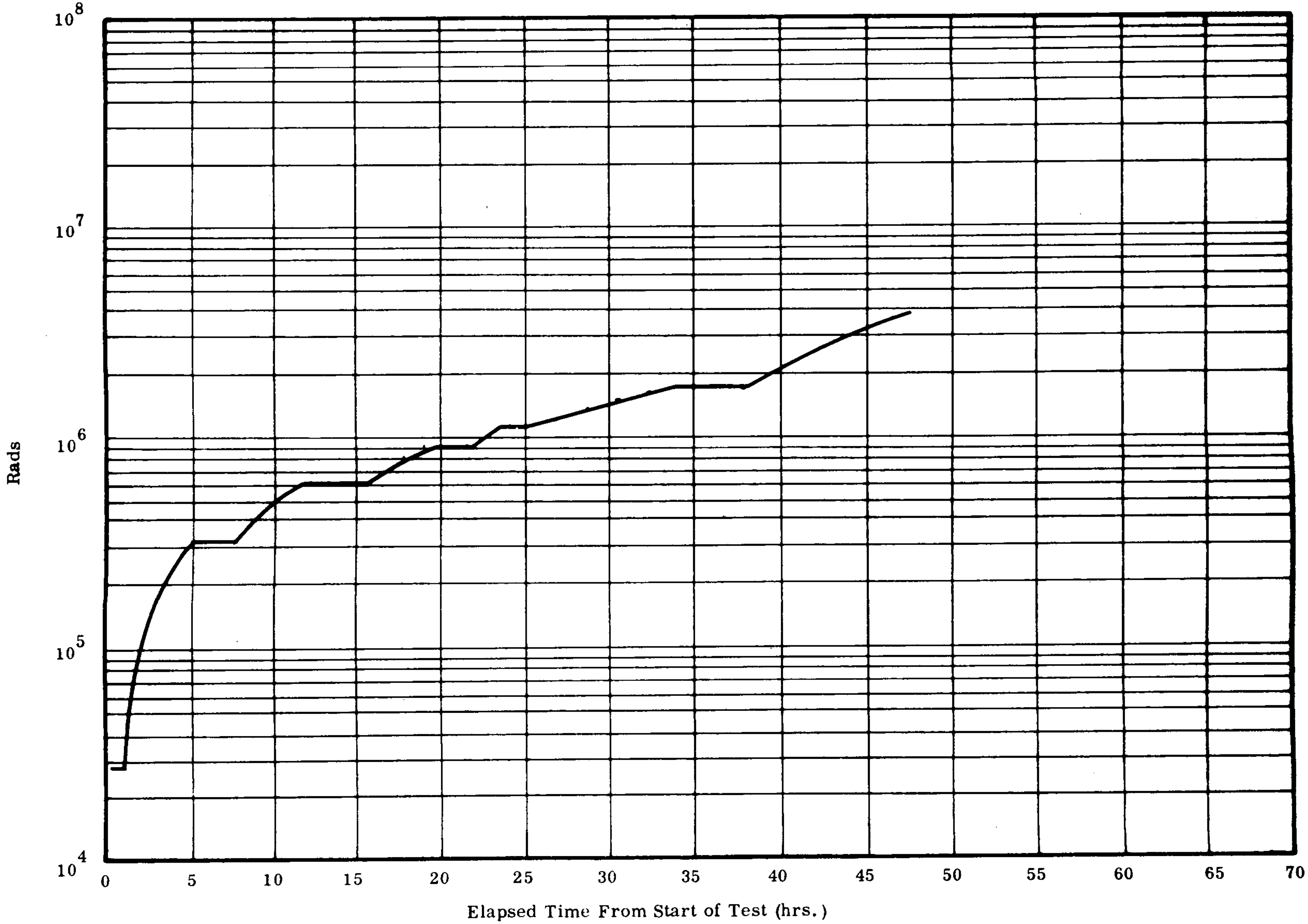


FIGURE 5-3 GAMMA DOSE VERSUS TIME - AEROJET TEST 2, CENTER OF TEST PANEL

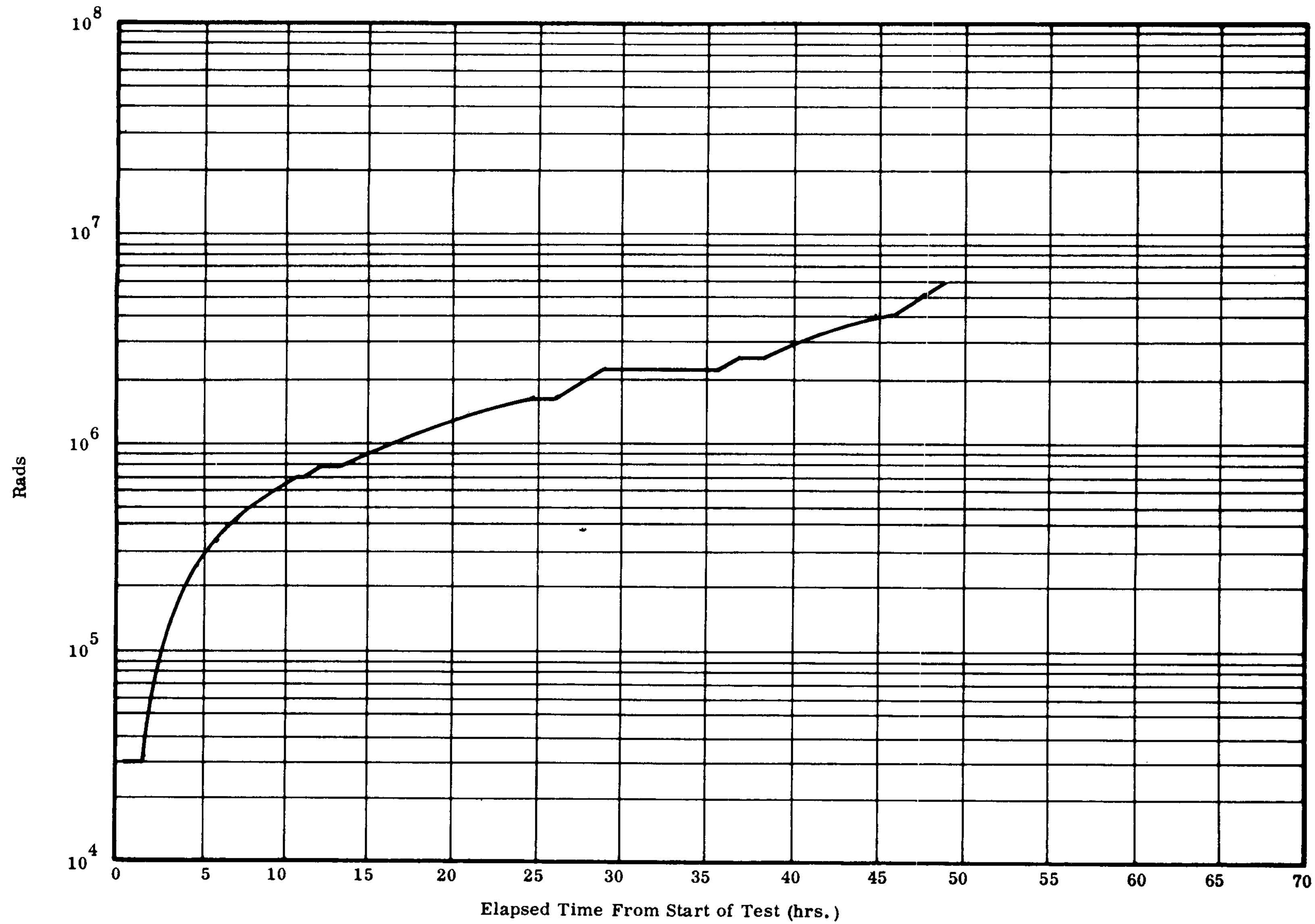


FIGURE 5-4 GAMMA DOSE VERSUS TIME - AEROJET TEST 3, CENTER OF TEST PANEL

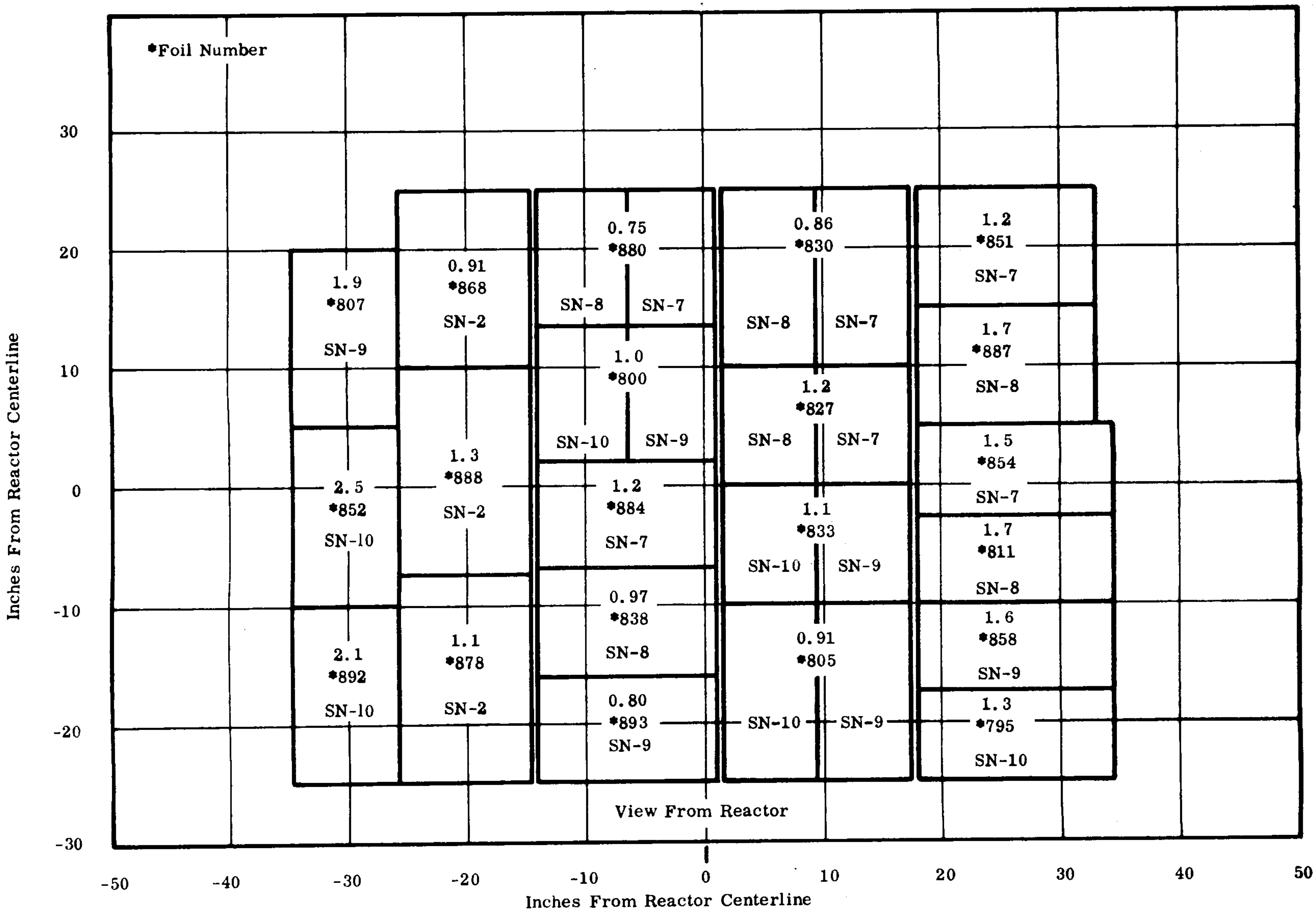


FIGURE 5-5 AEROJET IRRADIATION NO. 2 (160° F), INTEGRATED NEUTRON FLUX, > 0.1 MeV X 10^{-12}

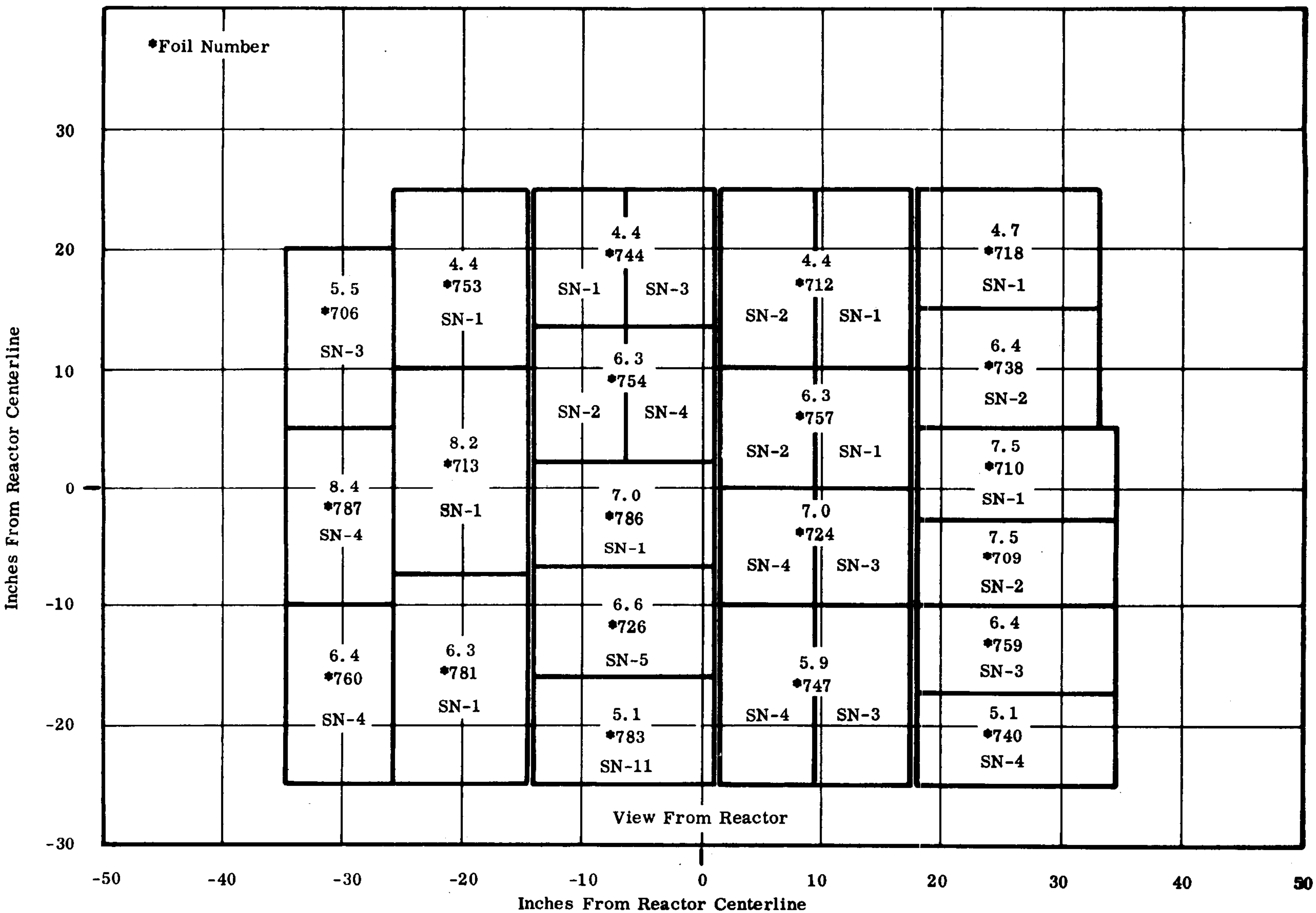


FIGURE 5-6 AEROJET IRRADIATION NO. 3 (100° F), INTEGRATED NEUTRON FLUX >0.1 MeV X 10^{-13}

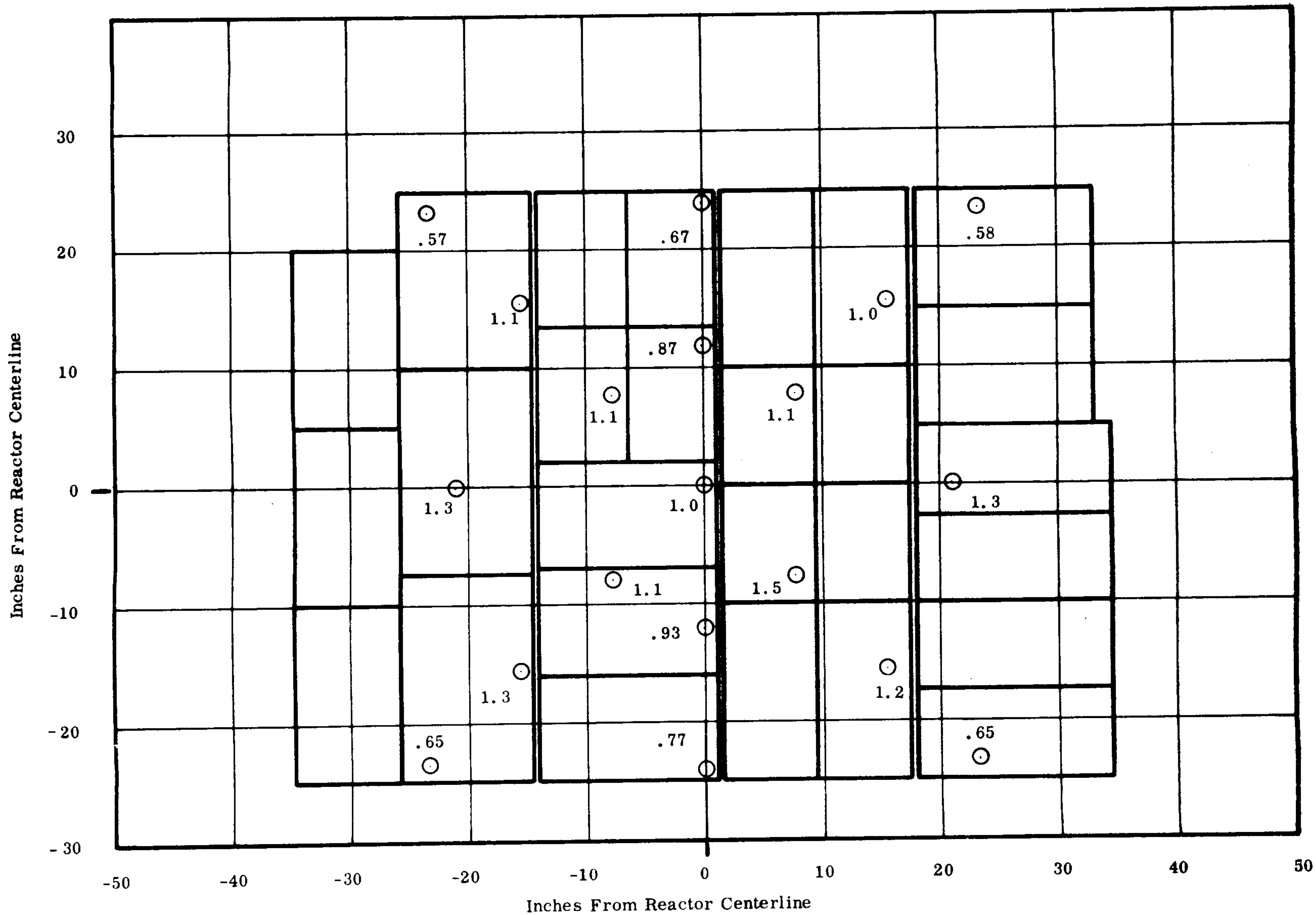


FIGURE 5-7 GAMMA DOSE DISTRIBUTION FOR AEROJET TESTS 2 AND 3, NORMALIZED TO UNITY AT THE TEST PANEL CENTERS

TABLE 5-1 ACCUMULATED EXPOSURE VS. TIME 160°F RUN

Shield	MW Level	Date and Time		(1) Accumulated Neutron Exposure (n/cm^2)	(2) Accumulated Gamma Dose Rads
With LiH	1 MW	7 July	0004	0	0
		7 July	0028	8.4 (9)	2.8 (4)
		7 July	0103	8.4 (9)	2.8 (4)
		7 July	0510	9.5 (10)	3.16 (5)
		7 July	0745	9.5 (10)	3.16 (5)
		7 July	1205	1.86 (11)	6.2 (5)
		7 July	1547	1.86 (11)	6.2 (5)
		7 July	1958	2.7 (11)	9.1 (5)
		7 July	2138	2.7 (11)	9.1 (5)
		7 July	2338	3.2 (11)	1.05 (6)
		8 July	0105	3.2 (11)	1.05 (6)
		8 July	1007	5.1 (11)	1.69 (6)
	3 MW	8 July	1408	5.1 (11	1.69 (6)
		8 July	2400	1.13 (12)	3.7 (6)

(1) Based on location of foil (878).

(2) Based on dose at center of panel.

TABLE 5-2 ACCUMULATED EXPOSURE VS. TIME 100°F RUN

Shield	MW Level	Date and Time	(1) Accumulated Neutron Exposure (n/cm^2)	(2) Accumulated Gamma Dose Rads
With LiH	1 MW	14 July 2334	0	0
		14 July 2400	9.1 (9)	3.04 (4)
		15 July 0120	9.1 (9)	3.04 (4)
		15 July 1044	2.1 (11)	6.90 (5)
		15 July 1054	2.1 (11)	6.90 (5)
		15 July 1200	2.3 (11)	7.60 (5)
		15 July 1244	2.3 (11)	7.60 (5)
		16 July 0012	4.7 (11)	1.57 (6)
	3 MW	16 July 0100	4.7 (11)	1.57 (6)
		16 July 0358	6.6 (11)	2.19 (6)
		16 July 1045	6.6 (11)	2.19 (6)
		16 July 1204	7.4 (11)	2.47 (6)
		16 July 1259	7.4 (11)	2.47 (6)
Without LiH	1 MW	16 July 1905	1.13 (12)	3.75 (6)
		16 July 2101	1.23 (13)	4.20 (6)
	3 MW	16 July 2105	1.23 (13)	-
		16 July 2400	6.3 (13)	6.0 (6)

(1) Based on location of foil (781)

(2) Based on dose at center of panel

ADDENDUM

January 1965

FORWARD VOLTAGE DROP AND REVERSE LEAKAGE CURRENT

Two each of the diode types previously irradiated in the SNAP-8 Radiation Effects Tests were subjected to forward voltage drop and reverse leakage current tests. Extreme electrical test conditions were employed to determine the effect of radiation on avalanche voltage and forward burnout current.

Two specimens from the $160^{\circ}F$ test, the $100^{\circ}F$ test and the $100^{\circ}F$ control group were tested. The test methods were as previously employed in the bench tests.

The results are tabulated in Tables A-1 through A-16.

The test results are easily understood if the radiation induced trend toward intrinsic operation is remembered. The avalanche voltage increased with exposure and began to be ill defined just as the intrinsic concept would indicate.

The forward voltage drop, for a given current, decreased as the test proceeded because the junctions became heated and annealed out a considerable amount of the radiation induced change. In general, as the forward currents were increased, the diodes improved. Diode burnout power appeared to be affected little, if any, but was not computed since the junction temperature was the controlling factor and the many variables affecting this parameter were not controlled.

TABLE A-1 FORWARD CHARACTERISTICS DIODE TYPE 1N547

Forward Current I_f (Amps)	Forward Voltage Drop - V_f (VDC)					
	Control Diodes		Irradiated Diodes			
	$100^{o}F$ Test		$160^{o}F$ Test		$100^{o}F$ Test	
	(5)	(6)	(7)	(8)	(1)	(2)
0.100	0.773	0.766	1.03	0.987	2.54	2.90
0.250	0.830	0.812	1.18	1.15	3.97	3.98
1.00	0.950	0.920	1.58	1.54	3.50*	4.57
2.00	1.08	1.00	1.80*		2.70	6.70*
3.00	1.18	1.09		1.70	2.30	2.20
4.00	1.29	1.18	1.60		2.00	
5.00	1.43	1.28		1.78*		
6.00	1.59	1.41	1.80	1.65		
7.00	1.74	1.57	1.80	1.73		
8.00	1.70*	1.71*		1.74		
9.00	1.70	1.73		1.75		
10.00	1.70	1.74				

* Apparently destroyed.

TABLE A-2 REVERSE CHARACTERISTICS DIODE TYPE 1N547

Reverse Voltage Vf (VDC)	Reverse Leakage - I_R (Amps)					
	Control Diodes		Irradiated Diodes			
	100°F Test		160°F Test		100°F Test	
	(5)	(6)	(7)	(8)	(1)	(2)
200	6.25 (-9)	6.7 (-9)	3.2 (-8)	2.1 (-8)	1.72 (-7)	1.62 (-7)
400	8.7 (-9)	1.02 (-8)	5.7 (-8)	3.2 (-8)	2.6 (-7)	2.5 (-7)
600	1.08 (-8)	1.32 (-8)	7.9 (-8)	4.1 (-8)	3.4 (-7)	3.2 (-7)
800	1.30 (-8)	1.62 (-8)	1.02 (-7)	5.0 (-8)	4.2 (-7)	4.1 (-7)
1000	1.54 (-8)	2.07 (-8)	1.28 (-7)	5. 8 (-8)	5.3 (-7)	5.2 (-7)
1100						6.2 (-7)
1200	1.83 (-8)	2.9 (-8)	1.54 (-7)	6.6 (-8)	*6.7 (-7)	*7.5 (-7)
1300			1.77 (-7)			
1400			1.95 (-7)	7.3 (-8)		
1450		*				
1500	2.95 (-8)		2.25 (-7)			
1600				8.3 (-8)		
1650			4.5 (-7)			
1700				*9.8 (-8)		
1800	*					

* Avalanche

TABLE A3 FORWARD CHARACTERISTICS DIODE TYPE 1N2539

Forward Current I_f (Amps)	Forward Voltage Drop - V_f (VDC)					
	Control Diodes		Irradiated Diodes			
	100°F Test		160°F Test		100°F	
	(5)	(6)	(7)	(8)	(1)	(2)
1.0	0.870					
2.0	0.900					
4.0	0.934	0.893	1.144	1.02	3.750	2.49
6.0	0.954					2.24
8.0	0.972	0.910	1.270	1.10		2.05
4.0	0.932	0.894	1.320	1.01		1.79
12.0	1.014	0.922	1.330	1.14		1.83
4.0	0.932	0.894	1.096	1.00		1.57
16.0	1.061	0.932	1.350	1.16		1.56
4.0	0.932	0.894	1.072	0.98		1.25
20.0	1.160	0.944	1.360	1.16	1.840	1.46
4.0	0.934	0.894	0.987		1.310	1.09
24.0	1.200	0.955		1.16		1.47
4.0	0.918	0.894		0.92		1.02
28.0	1.370	0.993		1.29		1.51*
4.0				0.92		
32.0	1.330	1.006		1.35 (s)		
4.0	0.931*	0.892				
36.0		1.056				
4.0		0.893				

* Reverse leakage excessive.
(s) Shorted

TABLE A-4 REVERSE CHARACTERISTICS DIODE TYPE 1N2539

Reverse Voltage Vf (VDC)	Reverse Leakage - I_R (Amps)					
	Control Diodes		Irradiated Diodes			
	100°F Test		160°F Test		100°F Test	
	(5)	(6)	(7)	(8)	(1)	(2)
200	1.32 (-8)	4.2 (-8)	2.7 (-8)	5.5 (-8)	3.85 (-7)	
400	1.83 (-8)	1.02 (-7)	4.2 (-8)	1.14 (-7)	5.7 (-7)	6.6 (-7)
500		1.44 (-7)	5.1 (-8)	1.66 (-7)		
550		1.70 (-7)				
600	2.46 (-8)	*2.25 (-7)	6.6 (-8)	2.5 (-7)	7.4 (-7)	1.02 (-6)
650				3.0 (-7)		
700			9.6 (-8)	3.8 (-7)		1.29 (-6)
750			1.26 (-7)	4.8 (-7)		1.50 (-6)
775	*3.63 (-8)					
800			*1.74 (-7)	6.1 (-7)	9.0 (-7)	*
850				7.8 (-7)		
900				*9.7 (-7)	1.0 (-6)	
1000					1.11 (-6)	
1100					1.26 (-6)	
1200					1.44 (-6)	
1250					*	

* Avalanche

TABLE A-5 FORWARD CHARACTERISTICS DIODE TYPE GE-90

Forward Current I_f (Amps)	Forward Voltage Drop - V_f (VDC)					
	Control Diodes		Irradiated Diodes			
	100°F Test		160°F Test		100°F Test	
	(5)	(6)	(7)	(8)	(1)	(2)
0.100	0.803	0.807	0.912	0.805	1.52	1.48
0.200	0.831	0.831	1.08	0.855	1.83	1.79
0.500	0.858	0.870	1.20	0.920	2.17	2.30
1.00	0.895	0.931	1.28	1.00	2.00	1.70
1.50	0.938	0.990	1.38	-	1.60	-
2.00	1.00	1.08	1.46	1.10	1.50*	1.50
2.50	1.13	1.20	1.61	1.13	1.60	-
3.00	1.30	1.50*	2.01	1.16	1.50	1.60
4.00		1.50	Open	1.20*	1.50	2.00
5.00		1.50		(s)		1.90
6.00		1.60				1.80
7.00						(s)

* Apparently destroyed.
(s) Shorted

TABLE A-6 REVERSE CHARACTERISTICS DIODE TYPE GE-90

Reverse Voltage Vf (VDC)	Reverse Leakage - I_R (Amps)					
	Control Diodes		Irradiated Diodes			
	100°F Test		160°F Test		100°F Test	
	(5)	(6)	(7)	(8)	(1)	(2)
200	2.25 (-9)	1.80 (-9)	2.75 (-9)	2.05 (-8)	2.55 (-8)	2.55 (-8)
300	5.00 (-9)	3.00 (-9)	4.10 (-9)	4.45 (-8)	3.90 (-8)	4.05 (-8)
350	7.85 (-9)		5.45 (-9)	6.65 (-8)	5.50 (-8)	
400	1.50 (-8)	5.55 (-9)	7.70 (-9)	9.90 (-8)	6.70 (-8)	7.65 (-8)
428	2.58 (-8)					
445					9.50 (-8)	
450	*	8.30 (-9)	1.20 (-8)	1.65 (-7)		
490				2.67 (-7)		
500		1.39 (-8)	2.34 (-8)	2.95 (-7)	1.74 (-7)	2.70 (-7)
530					2.61 (-7)	
550		2.82 (-8)	5.60 (-8)	6.25 (-7)	3.70 (-7)	7.7 (-7)
590						2.97 (-6)
600		7.55 (-8)	1.92 (-7)	1.53 (-6)	9.25 (-7)	9.70 (-6)
610		2.10 (-7)			8.90 (-6)	2.55 (-5)
625		2.79 (-7)		2.85 (-6)	*2.82 (-5)	
630		*				8.5 (-5)
640			2.13 (-7)			
645			*	*		
650						2.25 (-4)
700						*

* Avalanche

TABLE A-7 FORWARD CHARACTERISTICS DIODE TYPE 1N2592

Forward Current I_f (Amps)	Forward Voltage Drop - V_f (VDC)					
	Control Diodes		Irradiated Diodes			
	$100^{\circ}F$ Test		$160^{\circ}F$ Test		$100^{\circ}F$ Test	
	(5)	(6)	(7)	(8)	(1)	(2)
12	1.035		1.34	1.185	1.79	2.47
36	1.48		1.27		1.24	
12	1.021		0.93		1.03	
50	1.06					
60			1.40**	1.160 (M)	(M)	0.79 (M)
12	1.185		0.942			

(M) Melted at base plate.
** Diode physically displaced at base plate.

TABLE A-8 REVERSE CHARACTERISTICS DIODE TYPE 1N2592

Reverse Voltage Vf (VDC)	Reverse Leakage - I_R (Amps)					
	Control Diodes		Irradiated Diodes			
	100°F Test		160°F Test		100°F Test	
	(5)	(6)	(7)	(8)	(9)	(10)
200	4.05 (-9)		1.19 (-7)	5.9 (-8)	5.9 (-7)	1.5 (-7)
400	7.2 (-9)	7.5 (-7)	1.62 (-7)	8.2 (-8)	7.2 (-7)	2.6 (-7)
600	1.15 (-8)	9.9 (-7)	2.01 (-7)	9.3 (-8)	8.2 (-7)	3.7 (-7)
800	2.4 (-8)	1.28 (-6)	2.4 (-7)	1.07 (-7)	9.7 (-7)	5.1 (-7)
900	9.0 (-8)				1.14 (-6)	6.2 (-7)
1000		*1.44 (-6)	2.8 (-7)	1.32 (-7)	1.29 (-6)	7.9 (-7)
1050				*	1.45 (-6)	1.23 (-6)
1075					*	
1080						4.0 (-6)
1200			*3.3 (-7)			

* Avalanche

TABLE A-9 FORWARD CHARACTERISTICS DIODE TYPE 1N3878

Forward Current I_f (Amps)	Forward Voltage Drop - V_f (VDC)					
	Control Diodes		Irradiated Diodes			
	100^{o}F Test		160^{o}F Test		100^{o}F Test	
	(5)	(6)	(7)	(8)	(1)	(2)
6	1.22		1.50	1.36	2.31	2.46
14				1.51		2.23
6				1.34		1.86
20	1.41		1.98	1.75	2.20	2.05
6	1.22		1.47	1.33	1.55	1.45
30			1.75	1.81	1.80	1.61 (s)
6			1.34 (s)	1.27		
36	1.36 (s)			1.65*	1.63	
40					1.56 (s)	

(s) Shorted
* Reverse leakage excessive.

TABLE A-10 REVERSE CHARACTERISTICS DIODE TYPE 1N3878

Reverse Voltage Vf (VDC)	Reverse Leakage - I_R (Amps)					
	Control Diodes		Irradiated Diodes			
	100°F Test		160°F Test		100°F Test	
	(5)	(6)	(7)	(8)	(1)	(2)
200		1.2 (-6)	8.5 (-7)	1.20 (-6)	1.50 (-6)	1.90 (-5)
300					2.15 (-6)	4.85 (-5)
400	9.0 (-7)	1.6 (-6)	2.85 (-6)	1.60 (-6)	2.85 (-6)	5.90 (-5)
500			8.45 (-6)		3.80 (-6)	5.85 (-5)
550			1.32 (-5)			
600	1.2 (-6)	2.6 (-6)	2.65 (-5)	2.90 (-6)	5.3 (-6)	6.20 (-5)
650	1.47 (-6)		4.25 (-5)			
700	1.98 (-6)	3.7 (-6)	7.75 (-5)	7.75 (-6)	9.15 (-6)	7.15 (-5)
750	3.1 (-6)		1.11 (-4)		1.20 (-5)	8.00 (-5)
800	5.8 (-6)	7.2 (-6)	1.77 (-4)		1.95 (-5)	1.02 (-4)
830	8.2 (-6)					
840					2.7 (-5)	
850	1.17 (-5)	1.3 (-5)	2.35 (-4)			1.57 (-4)
900	2.7 (-5)	3.0 (-5)	3.35 (-4)		5.4 (-5)	2.85 (-4)
935		9.0 (-5)				
940		2.3 (-4)				
950	6.0 (-5)	7.6 (-4)	5.15 (-4)		8.95 (-5)	6.0 (-4)
990						1.0 (-3)
1000	*		7.90 (-4)		2.25 (-4)	
1035			9.60 (-4)		*1.00 (-3)	

* Avalanche

TABLE A-11 FORWARD CHARACTERISTICS DIODE TYPE 1N3888

Forward Current I_f (Amps)	Forward Voltage Drop - V_f (VDC)					
	Control Diodes		Irradiated Diodes			
	100^oF Test		160^oF Test		100^oF Test	
	(5)	(6)	(7)	(8)	(1)	(2)
12	1.17		1.30	1.01	2.01	1.77
24			1.42			
12			1.30			
36	1.36		1.64	1.09	1.70	1.06 (M)
12	1.17		1.29	1.01	1.33	
45			1.58**			
60				1.16	1.37	
72	1.50**					
12				0.97 (s)	1.17*	

(s) Shorted.
(M) Melted loose at base.
(*) Apparently destroyed.
(**) Reverse leakage excessive.

TABLE A-12 REVERSE CHARACTERISTICS DIODE TYPE 1N3888

Reverse Voltage Vf (VDC)	Reverse Leakage - I_R (amps) Control Diodes 100°F Test		Irradiated Diodes 160°F Test		Irradiated Diodes 100°F Test	
	(5)	(6)	(7)	(8)	(1)	(2)
200	3.3 (-6)	5.7 (-6)	3.1 (-5)	2.75 (-6)	5.4 (-6)	4.5 (-6)
300			7.4 (-5)			4.98 (-6)
350						5.25 (-6)
400	7.5 (-6)	7.25 (-6)	1.22 (-4)	4.3 (-6)	8.7 (-6)	5.50 (-6)
450	1.2 (-5)					
500	1.7 (-5)	8.1 (-6)	*2.4 (-4)	6.8 (-6)		6.18 (-6)
550	1.9 (-5)					6.60 (-6)
600	2.7 (-5)	8.8 (-6)		9.6 (-6)	1.6 (-5)	7.20 (-6)
650						7.90 (-6)
700	*	9.6 (-6)		1.29 (-5)	2.4 (-5)	*9.50 (-6)
750				1.7 (-5)		
800		1.17 (-5)		2.8 (-5)	3.8 (-5)	
850				6.0 (-5)	4.8 (-5)	
875				*		
900		1.77 (-5)			6.5 (-5)	
950		2.46 (-5)			8.5 (-5)	
1000		4.5 (-5)			1.25 (-4)	
1050		9.0 (-5)			1.9 (-4)	
1100		9.6 (-5)			7.8 (-4)	

* Avalanche

TABLE A-13 FORWARD CHARACTERISTICS DIODE TYPE GE-91

Forward Current I_f (Amps)	Forward Voltage Drop - V_f (VDC)					
	Control Diodes		Irradiated Diodes			
	100°F Test		160°F Test		100°F Test	
	(5)	(6)	(7)	(8)	(1)	(2)
4.0	1.12	0.88	0.99	1.02		3.78
8.0		0.91	1.08	1.12	3.18	4.26
12.0	1.68	0.93	1.14	1.19	4.27	3.39
20.0	2.29	0.97	1.24		3.53	2.74
24.0	1.70	0.99	1.28		2.75	2.57
12.0		0.92	1.12		2.37	2.35
36.0		1.03	1.32	1.47	2.43	2.22
12.0		0.92	1.08	1.52	2.06	2.02
40.0	1.43	1.06	1.37			2.19
48.0		1.11	1.40	1.52	2.32	1.87
12.0		0.93	1.09	1.12	1.82	1.35
56.0	1.29	1.17	1.47			1.88
60.0	1.33	1.20	1.49	1.59	2.12	1.84
12.0		0.93	1.06	1.11	1.41	1.13
64.0		1.24				1.87
66.0	1.48					
68.0		1.30				1.85
72.0	1.77*	1.38	1.60	1.62	1.96	1.84
12.0		0.93	1.02	1.03	1.11*	0.95*

* Low reverse resistance.

TABLE A-14 REVERSE CHARACTERISTICS DIODE TYPE GE-91

Reverse Voltage Vf (VDC)	Reverse Leakage - I_R (Amps)					
	Control Diodes		Irradiated Diodes			
	100°F Test		160°F Test		100°F Test	
	(5)	(6)	(7)	(8)	(1)	(2)
200	1.70 (-7)	8.0 (-8)	2.40 (-7)	2.55 (-7)	9.0 (-7)	7.5 (-7)
250	2.50 (-7)					
300	3.20 (-7)					
400	4.65 (-7)	1.5 (-7)	3.90 (-7)	3.45 (-7)	1.30 (-6)	1.15 (-6)
500	6.60 (-7)					
550	8.20 (-7)					
600	1.14 (-6)	2.65 (-7)	5.25 (-7)	4.20 (-7)	2.05 (-6)	1.50 (-6)
650	1.92 (-6)					
700	4.55 (-6)	3.30 (-7)			2.55 (-6)	
750	8.65 (-6)					
800	1.06 (-5)	4.00 (-7)	6.60 (-7)	4.80 (-7)	3.30 (-6)	1.90 (-6)
900	1.44 (-5)	4.70 (-7)			4.50 (-6)	
1000	1.77 (-5)	5.60 (-7)	7.95 (-7)	1.17 (-6)	6.40 (-6)	2.40 (-6)
1050				2.86 (-6)	7.85 (-6)	
1100	2.25 (-5)	6.75 (-7)	9.30 (-7)	8.05 (-6)	9.90 (-6)	2.85 (-6)
1150				2.86 (-5)	1.30 (-5)	
1200	2.61 (-5)	9.70 (-7)	1.20 (-6)	6.90 (-5)	1.87 (-5)	3.60 (-6)
1250			1.44 (-6)	1.48 (-4)	2.73 (-5)	
1295				2.62 (-4)		
1300	2.90 (-5)	*	1.78 (-6)		4.50 (-5)	4.90 (-6)
1350			2.44 (-6)	5.05 (-4)	8.50 (-5)	
1400	*		*		2.02 (-4)	7.60 (-6)
1500						1.42 (-5)
1550						2.14 (-5)

* Avalanche

TABLE A-15 FORWARD CHARACTERISTICS DIODE TYPE GE-92

Forward Current I_f (Amps)	Forward Voltage Drop - V_f - (VDC)					
	Control Diodes		Irradiated Diodes			
	$100^{o}F$ Test		$160^{o}F$ Test		$100^{o}F$ Test	
	(5)	(6)	(7)	(8)	(1)	(2)
35	0.98		1.31	1.10	3.4	2.06
50						1.87
35						1.88
70	1.14			1.18		1.76
35	0.96			1.08		1.65
105	1.26		1.53	1.22	2.02	1.59
35	0.95		1.22		1.60*	1.49
130				1.24		1.40
140	1.50					
35	0.96					

* Reverse leakage excessive.

TABLE 16 REVERSE CHARACTERISTICS DIODE TYPE GE-92

Reverse Voltage Vf (VDC)	Reverse Leakage - I_R (Amps)					
	Control Diodes		Irradiated Diodes			
	100°F Test		160°F Test		100°F Test	
	(5)	(6)	(7)	(8)	(1)	(2)
100	4.6 (-7)		4.15 (-7)			
150	7.0 (-7)	2.0 (-6)				
200	9.7 (-7)	4.3 (-6)	6.0 (-7)	8.8 (-7)	1.2 (-6)	1.32 (-6)
250	1.3 (-6)	6.0 (-6)		1.25 (-6)		
300	1.68 (-6)	7.5 (-6)	9.3 (-7)	1.72 (-6)		
350	2.06 (-6)	8.7 (-6)				
400	2.50 (-6)	9.9 (-6)	1.48 (-6)	3.4 (-6)	3.6 (-6)	2.17 (-6)
450	2.9 (-6)	1.02 (-5)	1.78 (-6)			
500	3.4 (-6)	1.08 (-5)	2.08 (-6)	5.6 (-6)	5.8 (-6)	
550	4.05 (-6)	1.17 (-5)				
600	4.8 (-6)	1.38 (-5)	2.65 (-6)	8.2 (-6)	9.9 (-6)	3.03 (-6)
650	5.7 (-6)	1.50 (-5)	2.8 (-6)		1.56 (-5)	
700	6.7 (-6)	1.62 (-5)	3.0 (-6)	1.08 (-5)	2.7 (-5)	3.57 (-6)
725	*				*	
750		1.62 (-5)				
800		*1.90 (-5)	3.5 (-6)	1.38 (-5)		4.30 (-6)
900			3.8 (-6)	1.65 (-5)		5.55 (-6)
950						6.50 (-6)
1000			4.5 (-6)	1.8 (-5)		7.82 (-6)
1100			5.3 (-6)	2.35 (-5)		1.31 (-5)
1150						1.83 (-5)
1200			6.7 (-6)	2.5 (-5)		2.69 (-5)
1250			7.8 (-6)			4.21 (-5)
1300			9.5 (-6)	3.3 (-5)		7.31 (-5)
1335				*		
1350			1.26 (-5)			1.38 (-4)
1375						2.84 (-4)
1400			1.81 (-5)			9.50 (-4)
1450			3.0 (-5)			
1475			*			

* Avalanche

VOLTAGE SENSING UNIT

There was a null shift in the Voltage Sensing Units evident during pre and post bench tests. A null shift was also evident between bench data and data taken at the reactor. The test results at the reactor showed a progressive null shift. From the evidence available, it appeared that a resistive unbalance, or an unbalance in forward characteristics of the diodes, caused the detected shift.

Additional bench tests were run to prove this hypothesis.

The diodes were interchanged and did indeed produce a null shift in the opposite direction. The load resistance was varied from 140 ohms to 200 ohms in 20 ohm steps. The data from these tests are tabulated in Tables A-17, A-18, and A-19.

The data prove the hypothesis were correct.

TABLE A-17 POST IRRADIATION TEST - VOLTAGE SENSING UNIT S/N #A2

Input VAC	Output (I_1) (MADC)		V_4 (VDC)		V_5 (VDC)		V_6 (VDC)		
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	
188	16.2	19.7	20.51	20.91	18.17	17.91	2.33	3.00	
190		17.8		21.19		18.49		2.71	
192		16.2		21.44		18.98		2.47	
194		14.8		21.62		19.40		2.23	
196	8.92	13.4	21.59	21.88	20.22	19.85	1.34	1.99	
198		11.6		22.17		20.41		1.72	
200		9.90		22.41		20.93		1.48	
202		8.40		22.67		21.41		1.26	
204	1.65	6.40	22.78	23.00	22.51	22.00	0.24	0.99	
206		5.60		23.19		22.41		0.76	
207	0.00		23.02		23.02		0.00		150 Ohm Load
208		3.55		23.48		22.93		0.54	
210		1.90		23.74		23.47		0.27	
212		0.00		24.02		24.02		0.00	
214	-5.20	-1.04	24.08	24.19	24.86	24.33	-0.82	-0.15	
216		-2.61		24.43		24.83		-0.39	
218		-4.22		24.72		25.35		-0.65	
220		-5.95		25.00		25.90		-0.90	
222	-12.4	-7.90	25.17	25.31	26.99	26.49	-1.84	-1.20	
224	-13.7	-9.54	25.26	25.58	27.31	27.02	-2.06	-1.43	

(1) Diodes in original position.
(2) Diodes in each respective halves interchanged.

TABLE A-18 POST-IRRADIATION TEST - VOLTAGE SENSING UNIT S/N #A2

Input VAC	Output (I_1) (MADC)		V_4 VDC		V_5 VDC		V_6 VDC		
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	
204	3.17		22.74		22.29		0.42		140 Ohm Load
208	0.00		23.24		23.24		0.00		
210		2.82		23.80		23.42		0.41	
212	-4.60		23.98		24.60		-0.64		
214		0.00		24.51		24.51		0.00	
216		-1.23		24.61		24.78		-0.17	
204	1.60		22.50		22.24		0.24		160 Ohm Load
206	0.00		22.75		22.75		0.00		
208	-1.90		23.11		23.43		0.31		
210		2.22		23.65		23.30		0.33	
212		0.00		23.99		23.99		0.00	
214		-1.67		24.23		24.49		-0.25	

(1) Diodes in original position.
(2) Diodes in each respective halves interchanged.

TABLE A-19 POST IRRADIATION TEST - VOLTAGE SENSING UNIT S/N #A2

Input VAC	Output (I_1) (MADC)		V_4 VDC		V_5 VDC		V_6 VDC		
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	
204	0.47		22.45		22.39		0.60		180 Ohm Load
205	0.00		22.51		22.51		0.00		
206	-0.90		22.68		22.84		-0.16		
210		1.16		23.55		23.33		0.19	
211		0.00		23.75		23.75		0.00	
212		-0.99		23.92		24.07		-0.17	
202	1.28		22.14		21.88		0.24		200 Ohm Load
204	0.00		22.35		22.35		0.00		
206	-0.95		22.58		22.75		-0.18		
210		0.65		23.49		23.34		0.11	
210.5		0.00		23.60		23.60		0.00	
212		-1.17		23.83		24.04		-0.22	

(1) Diodes in original position.
(2) Diodes in each respective halves interchanged.

MAGNETIC AMPLIFIER CORE FLUIDS

The magnetic amplifier cores from specimens Serial Numbers A-2, A-6 and A-10 were opened and the fluid examined.

A small hole was drilled into the core of each covering and the core placed over a beaker to drain. Serial No. A-2, or the 100^{o}F test specimen, would not drain and had to be opened by machining. The fluid from the control specimen (A-6) was clear and viscous while that from the 160^{o}F test core (A-10) was slightly darkened and somewhat more viscous. The A-2 specimen fluid jelled and had to be scraped out. A color comparison could not be made due to the reflective and translucent properties of the surface of the scraping. There was no evidence of color change, cracking or flaking of the wire insulation.